UNIVERSITY OF BRISTOL

THE ANNUAL REPORT

OF THE

Agricultural and Horticultural Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL

1943

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INTRODUCTION.

By T. WALLACE, M.C., D.Sc., A.R.I.C., Director.

The period covered by the present Annual Report has been marked by important changes in senior staff appointments in the Department. Professor B. T. P. Barker, M.A., who had been Director of the National Fruit and Cider Institute since 1903 and Head of the Department of Agriculture and Horticulture since 1912, retired on reaching the age limit, on September 30th, 1943. He was succeeded by the present Director, who had filled the post of Deputy Director at the Institute since 1924. Mr. A. W. Ling, M.Sc., N.D.A., Chief Agricultural Advisory Officer and Head of the Berkeley Square Advisory Office, was appointed Principal of the Seale Hayne Agricultural College, Newton Abbot, Devon, from September 1st, 1943. Mr. Ling has retained his appointment in the Department and in addition has taken over the duties of Chief Advisory Officer for Devon and Cornwall, the area served by the Seale Hayne Advisory Centre. Mr. Ling's appointment has thus linked together the Advisory work of the Bristol and Seale Hayne centres.

Professor Barker's retirement has left a gap in the Department which is not easy to fill. He had witnessed the beginnings of both the National Fruit and Cider Institute and the Department of Agriculture and Horticulture, and as the first and only Director of both until his retirement, he had played the leading part in the development of the Research and Advisory organisations comprising the present-day Department. Under his guidance the Long Ashton Institute, where in the earliest days he was the only scientific worker, has grown from very small beginnings into a National Research Station with a world-wide reputation. Out of it has also grown the Campden Research Station, now the recognised National Station serving the Canning Industry. The growth of the Advisory Centre has been no less remarkable: in 1913 there were two advisory officers, a chemist and an entomologist, who were attempting to contact the farming community, whereas in 1943 the Advisory Service covered thirteen subjects in Agriculture and Horticulture and dealt with over 10,000 enquiries in addition to carrying our numerous research projects and engaging in various educational activities.

Professor Barker on his retirement can feel justly proud of the organisation he has laboured to build and has built so well. His valuable contribution to Horticulture was marked by the award of a Veitch Gold Medal in November, 1943, by the Royal Horticultural Society.

The present staff of the Department take this opportunity of recording their appreciation of the great work which Professor Barker did as their leader for so many years and of wishing him many years of happiness in his retirement.

It was appropriate that Professor Barker, before his retirement, should have written an account of the war-time activities of the Department in a publication of the Bath and West and Southern Counties Society, the parent body of the National Fruit and Cider Institute.* The article includes a brief

*B. T. P. Barker. Agricultural and Horticultural Research in War Time, Pamphlet No. 10, Bath and West Society, September, 1943.

outline of the early history of the Institute, which has a particular interest for the older members and a special value as a record for those who continue the work at the present time.

The research work in the Department during the year has continued to be closely concerned with current problems of crop production in connection with the Food Production programme of the Ministry of Agriculture. This has meant that many of the longer-term peace-time projects at the Research Station have remained in abeyance and that problems outside the scope of the normal research programme have received attention. Most of the senior staff have also served on special committees of the Ministry of Agriculture, the Agricultural Research Council and the Agricultural Improvement Council, and of other Government Departments dealing with technical problems.

On the advisory side, the Advisory Officers have collaborated in many national schemes of the Ministry of Agriculture and contacts have been maintained and developed with the County Technical Development Sub-Committees of the Bristol Province. The Chief Advisory Officer represents the Advisory Centre on all County Technical Development Sub-Committees in the Province and in this way the Centre has been kept in very close touch with the County Advisory Services. It will be seen from the report on Advisory and Educational work that the number of advisory enquiries continues to increase.

A noteworthy feature in connection with the Advisory Service has been the revival of the Provincial Advisory Conference, meetings of which were discontinued, at the request of the Ministry of Agriculture, on the outbreak of war. The Ministry recently decided that it was opportune to revive the conference at the present stage of the national food production campaign, in order to co-ordinate and intensify educational and advisory work within the Province. The first meeting was held on September 1st, 1943. The Conference is co-operating with officers of the Ministry in arranging exhibits for the use of County War Agricultural Executive Committees in their educational campaigns.

At each of the working centres of the Department good progress can be reported for the year. The financial position has remained satisfactory and the number and amount of subscriptions show further increases.

The articles appearing later in the report have been contributed by the Long Ashton and Berkeley Square Advisory Centre staffs : as in previous years the contributions of the Campden staff will appear in the report of the Campden Station.

BRISTOL ADVISORY CENTRE.

Since a summary of the main points in the Advisory work of the Department is given later in the Report the present account refers only to features which call for special mention.

No new schemes have come into operation during the year but special grants have been received in respect of the following : National Farm Survey ; Enterprise Cost Studies ; Milk Marketing Board Scheme for Milk Production Costs ; Survey of Fertiliser Practice ; National Milk Testing and Advisory Scheme.

The Surveys of Fertiliser Practice which are in progress are yielding useful

data regarding the use of fertilisers by individual farmers which should be of great value to County War Agricultural Executive Committees in the operation of their fertiliser distribution schemes. The National Milk Testing and Advisory Scheme has developed greatly during the year. It is administered by the Adviser in Dairy Bacteriology with the help of an assistant and five area supervisors. Area laboratories have been established in Bristol, Gloucester and Wincanton, and Testing Stations at Hereford and Trowbridge; forty-seven creameries and dairies have licensed laboratories; 90 per cent. of the producers' supplies in the Province have been covered by the organisation.

The appointment of Mr. R. W. Roach, B.Sc., M.R.C.V.S., as Assistant Veterinary Investigation Officer to Mr. Menzies, has enabled the Section to undertake an enlarged programme of investigations. Mr. Roach, in particular, has given much attention to problems of Mastitis.

Dr. H. W. Miles and his team have completed the first whole year of work under the extended Wireworm Scheme and have obtained data of practical value.

There has been an interesting development in connection with the Soil Survey investigations. The Ministry of Agriculture and the Ministry of Town and Country Planning have asked for the collaboration of Advisory Chemists and Soil Surveyors in their scheme of land classification, which is to serve as a basis for post-war development schemes. Dr. D. A. Osmond has already assisted in the preparation of Land Maps of Hereford, Worcester, Warwick and Stafford and in the detailed mapping of areas of potential development around several towns in the Midlands.

Staff.

The appointment of Mr. A. W. Ling as Principal of Seale Hayne Agricultural College, which entailed his taking up residence in the College, necessitated certain changes in staffing and administrative arrangements at Berkeley Square. Mr. Ling relinquished the post of Advisory Chemist on taking up his new duties and this was filled by the appointment of Mr. R. Stewart, B.Sc., Ph.D., who for several years has been Advisory Chemist at the Manchester University Provincial Advisory Centre. In addition to his duties as Advisory Chemist, Dr. Stewart will also assist Mr. Ling with the administration of the Advisory Centre. Under present arrangements Mr. Ling will spend one day each week at the Bristol Centre and in his absence Dr. Stewart will attend to general correspondence and matters of routine administration.

Tne only change in the senior staff at the Centre has been the appointment of Mr. Roach as Assistant Veterinary Investigation Officer.

A list of appointments and resignations during the year is given in the Summary Report on Advisory Work.

The prolonged illness of Miss Burnett, Administrative Secretary at the Advisory Centre, was reported in last year's Report. Unfortunately Miss Burnett has only made a partial recovery from her illness and has not been able to resume her former duties. Under the circumstances it was necessary to terminate her engagement in the Department. Her post was filled by Miss M. Tilley, who had already seen twelve years' service at Berkeley Square, and had carried out Miss Burnett's duties during the period of her illness. Miss Burnett had held her secretarial post since the establishment of the

Bristol Centre in 1923. She rendered long and valuable service to the Department, and her departure is a great loss to both the Department and her colleagues.

Buildings.

In spite of the fact that two years ago the Economics Section was transferred from Berkeley Square to new premises at 79, Woodland Road, Bristol, thereby freeing a number of rooms, they are now all full to overflowing on account of the expansion of the work at the Centre. Whilst it is realised that under present conditions little can be done in respect of increased accommodation, the housing of the Advisers and their staffs presents an ever-increasing problem. During the year, the University arranged for the complete redecoration of the basement of No. 21, Berkeley Square, which accommodates the Dairy Bacteriological section. This work was carried out very expeditiously and efficiently by the University Clerk of Works.

LONG ASHTON RESEARCH STATION.

Staff.

The retirement of Professor B. T. P. Barker from the post of Director on September 30th, 1943, and the appointment of Dr. T. Wallace, Deputy Director, as his successor from October 1st, 1943, has previously been mentioned. As the Ministry of Agriculture and the Agricultural Research Council decided that the post of Deputy Director, vacated by Dr. Wallace on his appointment to Director, should not be filled it was necessary to reorganise the office staff to relieve the Director of much of the routine administration of the Department. Mr. A. L. Leggett, hitherto Finance Secretary, was appointed Secretary and his staff strengthened and reorganised to cope with the additional work. Office duties are now divided into three sections: technical and academic under Miss A. M. Evans, general administration and sales under Mrs. A. I. Edbrooke, and accountancy under Mr. R. A. Merchant. Miss Evans is directly responsible to the Director, whilst Mrs. Edbrooke and Mr. Merchant serve under Mr. Leggett.

A further important staff change occurred on July 31st, 1943, with the resignation of Dr. V. L. S. Charley, Head of the Cider and Fruit Products Section, to take up a commercial post with Messrs. H. W. Carter & Co., Bristol, a firm which has been closely associated with the Station's research work in Fruit Products for several years. Messrs. Carter have kindly offered Dr. Charley's services to the Station in any problems in which his past experience can be of help, which offer the Station has been pleased to accept. By this arrangement it will be possible to keep in touch with Dr. Charley in his new post. Dr. Charley's resignation, coupled with Professor Barker's retirement, left the Station without an officer with special knowledge of cider, but this gap was filled by Professor Barker, who kindly consented to remain responsible for research work on cider, on a part-time basis, and to train an officer to take charge of the technical processes of cider making. Mr. L. F. Burroughs, who has hitherto been concerned with Fruit Products investigations, has been selected to undergo this training and is now working under Professor Barker's guidance.

Dr. A. Pollard has been given charge of Fruit Products work and has

been transferred from the Department of Scientific and Industrial Research grant to the Ministry of Agriculture's Graded Service grant.

During the year the special grant made by the Agricultural Research Council for investigations on copper and sulphur fungicides, under which Dr. R. L. Wain and Mr. E. H. Wilkinson were employed, was terminated. Dr. Wain was transferred to the Graded Staff personnel of the Station and Mr. Wilkinson as a Research Officer under the Scheme of Hop Virus Disease Investigations, which is financed through the Agricultural Research Council and in which the Long Ashton and East Malling Research Stations and Wye College are collaborating.

Miss D. P. Jones and Dr. R. L. Wain were absent on sick leave during the year. Mr. E. Catlow, Recorder, returned to the Station after a period of service in the Royal Air Force, and Mr. J. Packer, of the office staff, left to join that service for flying duties.

Buildings and Land.

There is a serious need for additional laboratory and office accommodation which under war-time conditions it is impossible to meet. In all sections additional staff has been provided during the war to carry out special investigations, and these additions have placed a great strain on the accommodation which even before the war was regarded as inadequate. It is fortunate that many of the present investigations entail a large proportion of field work, or the position could not have been met without building extensions. There is a pressing need for a Staff Common Room, as under present conditions the staff have no room available for rest or recreation. War-time conditions have also made it imperative to provide canteen facilities on the Station and an effort is being made to meet this need.

The general maintenance of buildings and roads will call for very considerable expenditure after the war since repairs had fallen in arrears prior to 1939 owing to lack of funds, and have been severely limited during the war due to Government restrictions. Every effort has been made to meet the most serious repair problems by means of a system of priorities.

The repair shops which have been adapted and equipped by Dr. Kearns have been invaluable in effecting overhauls and repairs to machinery and implements, and have provided Dr. Kearns with facilities for carrying out special research work on spraying machines and equipment for the Ministry of Agriculture and the County War Agricultural Executive Committees of the Province. The thanks of the Station are due to Dr. Kearns for the great help he has given in connection with the maintenance of property, machinery and implements.

Mr. J. H. Butler has continued his tenancy of the outlying portions of the Station farm.

No major changes have occurred in the working of the research plantations. The policy of cropping all open land with vegetables has been continued and work has proceeded smoothly with the help of several members of the Women's Land Army and local female labour. Research plots have been continued satisfactorily and both fruit and vegetable crops have yielded good returns.

The most serious labour problems have occurred in the Cider House, where the labour staff became depleted by deaths prior to the war. It has

been impossible to fill these vacancies, and although women helpers have come forward to perform many tasks, they cannot carry out much of the heavy work entailed. These circumstances have thrown a very heavy strain on the men who remain. The plantation staff have given all possible help, but the position remains very unsatisfactory and is a source of continuous anxiety.

Research Activities.

The main research items have been closely concerned with war-time problems. The Director has continued his studies on mineral deficiencies of plants and, at the request of the Agricultural Research Council, has published a Colour Atlas and Guide dealing with mineral deficiencies of the more important farm, vegetable and fruit crops.* During the year the work was extended to flax and the main visual effects of mineral deficiencies were determined for this crop. Surveys of deficiencies in farm crops were carried out by members of the Long Ashton team in several counties, including Gloucestershire, Somerset, Worcestershire, Hampshire, Shropshire, Derbyshire and parts of Lincolnshire, and demonstrations of deficiency symptoms in a variety of crops were given at Long Ashton to members of county staffs.

In connection with the control of pests and diseases, Dr. Kearns has continued his investigations on spraying machines and equipment, and the compounding of sprays and dusts. He has rendered valuable technical assistance to the Ministry of Agriculture on the design of spraying machines and equipment for both tree and ground crops and has trained members of the Women's Land Army for county spraying work. A small acid sprayer designed by Dr. Kearns for use on onion beds has been adopted by the Ministry and is to be produced for distribution to County War Agricultural Executive Committees.

Problems relating to spray materials have assumed great importance during the war years, and Dr. Martin and his colleagues have been actively engaged on investigations relating to the standardisation of important classes of spray materials and in the examination of possible new spray materials. Dr. Martin has served on several committees concerned with the standardisation of spray materials and the official approval of proprietary pest control products.

The Station has collaborated in the Scheme of the Agricultural Improvement Council to ensure supplies of healthy fruit stocks for the post-war period. Under this scheme the Station has undertaken to raise from seed supplies of rootstocks for apples, pears, plums and cherries in 1944.

During 1943, discussions have taken place with representatives of the Agricultural Research Council and the Department of Scientific and Industrial Research on the future of the work to be done at Long Ashton on Fruit Products. It is proposed that there should be some change in the nature of the work and that the Fruit Products staff should concentrate mainly on questions of quality in vegetables and fruits, with special reference to the effects of cultural conditions on quality. Advisory work on Fruit Products relating to results already obtained at Long Ashton will be continued and the character of the cider research programme will remain unchanged. Dr. Pollard will be responsible for the development of the new work.

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* Wallace T. The Diagnosis of Mineral Deficiencies in Plants. A Colour Atlas and Guide. H.M. Stationery Office, London, 1943.

In the Domestic Preservation Section the usual summer courses were given in 1943 and, in addition, six special courses in fruit preservation were held during the Spring for the special benefit of officers engaged in supervising preservation centres.

Miss Crang has revised Ministry of Agriculture Bulletin No. 21, " Domestic Preservation of Fruit and Vegetables," and has compiled a leaflet on "Canning at Fruit Preserving Centres."

Annual Field Day. Following war-time policy the Annual Tasting Day was not held. Members of the Institute, however, attended an Open Day on the occasion of the Annual Meeting of the National Fruit and Cider Institute on July 16th, 1943.

Visitors. The number of individual visitors to the Station was again less than in pre-war years, but many interviews have been given to growers and representatives of technical firms on a variety of problems.

The number of organised parties visiting the Station was well maintained. The list is as follows :—

Fishponds Diocesan Training College.
Bristol University Geography Students.
Bristol University Botany Students.
Reading University Students.
Guild of Blind Gardeners.
British Overseas Airways Corporation.
Plant Pathological Committee of the British Mycological Society.
Bristol University Youth Leader Training Group.
Bristol Constabulary Civil Defence Wardens.
Bristol Constabulary " D " Division.
Ministry of Agriculture and Fisheries Advisory Chemists.
Gloucester War Agricultural Executive Committee Officers.
Somerset War Agricultural Executive Committee Agricultural Officers.
Somerset War Agricultural Executive Committee Horticultural Officers.
Wiltshire War Agricultural Executive Committee Officers.
Pershore Young Farmers' Club.
Trowbridge Girls' High School.
Bristol Association of Scientific Workers.
National Association of Girls' Clubs.
The Robinson Waxed Paper Co. Ltd.
St. Michael's the Less Debating Society.
Bristol Association of Scientific Workers (Bristol Aeroplane Company).
Merchant Venturers Pharmacy Students' Association.
349 Searchlight Battery (2).

Shows, Demonstrations, etc. Exhibits have again been provided by the Station at various " Dig for Victory " and Produce Shows, and the following is a list of the places to which exhibits have been sent :—

Bristol (4)	Gloucester
Berkeley Road	Hanham
Congresbury	Kingswood
Chippenham	Moreton
Cheltenham	Salisbury
Cirencester	Swindon
Devizes	Tetbury
Filton	Yate

Demonstrations on methods of hedge and tree stump clearing, the improvement of farm orchards, spraying for control of diseases and pests in geenhouses, market gardens and farm crops were given by members of staff at the following places :—

Bitton	Frome
Charfield	Midsomer Norton
Dumbleton	Tewkesbury
Forthampton	West Monkton
Frenchay	

Research Students and Voluntary Workers. Mr. A. F. Parker-Rhodes, who has been a voluntary worker throughout the war period, left on January 31 to take up an appointment under the Ministry of Aircraft Production.

Parties of scholars from Clifton High School for Girls and the Red Maids' School, as well as Girl Guides from West Bristol, rendered very valuable assistance in the work in the fruit plantations during their summer vacation, and the Station wishes to record its grateful thanks for their continued voluntary services in this connection.

The thanks of the Station are due to Mr. J. E. Beviss, who has continued to help throughout the year in the practical and recording work in the plantations.

Acknowledgments.

The Department is indebted to many growers, industrial firms and other organisations and to many persons who have assisted in various ways during the year. The methods in which assistance has been given have been varied, including direct financial support, personal collaboration in experiments and surveys, provision of facilities for field trials, factory tests and operations, and personal advice and experience. Whatever the form of help given, it has all contributed to the success achieved during the year and sincere thanks are due to all who have so willingly co-operated.

The results achieved during the year could not have been obtained without special effort and sacrifices on the part of the staff, and special thanks are due to all grades for their loyal co-operation and support under the present difficult conditions.

OBSERVATIONS ON PLANTING DISTANCES IN APPLE PLANTATIONS IN THE BRISTOL PROVINCE.

By E. W. HOBBIS.

Introduction.

The number of apple trees to plant to an acre will always be open to debate and a re-adjustment of ideas might be necessary in later years, when development and performance reveal faults in the original plan. It is true to say, however, that the fruit grower has generally erred on the side of too close spacing of his trees, with the idea of covering the land as quickly as possible with productive wood.

Well-kept standard orchards can often demonstrate the advantages of wide planting for subsequent unhampered development of the trees. Provided site, soil, varieties and management have been satisfactory, standard trees planted 36′—40′ apart may just fall short of filling their allotted space in the 40th–50th year.

The commercial fruit-grower, however, is seldom interested in standard trees. For reasons of management and quick return on capital outlay, practically all commercial plantations established during the past 40 years have been on layered root-stocks, and during the past 20 years on standardised types of layered stocks resulting from the work of East Malling Research Station.

The use of layered rootstocks of selected types often gave the grower the impression that trees on them would require little room for development and would in any case be short-lived. Close planting therefore became the vogue. Such planting was coupled with a method of pruning heavily flavoured with accepted private garden practice, where tree symmetry was considered of first importance. Hard pruning, therefore, prevented or delayed overcrowding of many a plantation because *trees were pruned to restrict their development to a limited space.* In spite of this, growers have found trees on dwarfing stocks to be long enough lived and vigorous enough to lead ultimately to gross overcrowding.

Present-day pruning practice, based on utilizing more fully the early vigour of young trees in the rapid building up of framework branches and the retention of a fair proportion of lateral shoots intact or nearly so, will accentuate the overcrowding problem, unless tree development is visualised 20 years hence and allowance made in the original planting distance. Well-managed plantations under such pruning technique will develop far more rapidly than most growers appreciate.

Dwarf pyramid plantations on Malling Type II rootstock have become popular, in recent years, with the small-acreage grower looking for quick returns. Some have been highly successful and are still highly profitable in their 8th–10th year. How long the profitable life will be, is at present unknown

Fig. 1. Worcesters planted at 16′ x 11′. Note results of too close planting—narrow V limb formation and absence of young shoots on lower half of tree.

FIG. 2. Worcesters at 24′ apart. Note even development over whole tree.

FIG. 3. "Cutting-up" to give room. When a plantation reaches this stage it needs thinning.

and it is important to remember that the close-planted (6′ x 3′) dwarf pyramid depends on the annual formation of young wood to provide future fruiting surface. The trees are dwarfed both by rootstock and cultural practice and wood growth is regulated in amount by judicious manuring, combined with clean cultivation, sod mulching or cover cropping, and by a very flexible system of pruning. One fact has already been demonstrated, namely, that once the trees begin to lose their lower branches owing to overcrowding, cropping is reduced, unless the trees are thinned out or allowed to develop upwards. If this latter happens the system as such breaks down, as one of the principal aims is to accomplish all cultural and picking operations within reach of the ground. It is not the purpose of these notes, however, to go into this method of culture, but to discuss in particular the commercial bush plantation.

I. Planting Distance.

Points of importance to consider in relation to tree spacing when laying out new plantations can be grouped under the following headings :—

(*a*) Varieties and rootstock.
(*b*) Soil and climate.
(*c*) Working room for machinery.
(*d*) Pruning methods.

Cost of land is of secondary importance to these considerations. Land is cheaper than labour and will be more so in the future. Given sound choice of location, therefore, the grower should plant to ensure that any and every operation can be carried out with the least hindrance when tree development has attained its maximum. It follows, therefore, that trees should be planted far enough apart to avoid the necessity of "cutting up," *i.e.* the shortening back of outside branches, usually to an upward growing lateral, to give head-room between the trees. (See *Fig.* 3.)

The following table illustrates tree development in a block of bush trees of Worcester Pearmain, planted at Long Ashton in the winter of 1919–1920. The trees were planted at 15′ x 15′ (193 per acre), an equal number of trees being on each of the following layered rootstocks, Malling I, II, III, IV, V, VI, VII, IX, X, XII, and XIII, and Long Ashton G8. The plantation was laid down to grass in 1929.

Trees on rootstocks XII, XIII, and G8 had grown into one another by the autumn of 1936 when the average spread was 15′ 5″ and in the winter branch spread was reduced by pruning back. This accounts for the lower figure relating to spread for the autumn of 1937. In the winter of 1937 alternate trees on these three rootstocks were grubbed.

Trees on the weaker range of rootstocks did not overlap unduly until 1940, and the thinning of alternate trees was not done until the winter of 1942. Trees on Type IX rootstock are outstanding in the block, in that they are very dwarfed and have more than sufficient room at the original 15′ x 15′ spacing.

Data for all trees from 1936–1943 inclusive are shown in Table I.

TABLE I.

Rootstock.

Year.	XII, XIII, G8 Branch spread in feet.	Crop per acre in tons.	I,II, III, IV, V, VII, X Branch spread in feet.	Crop per acre in tons.	IX Branch spread in feet.	Cropper acre in tons.
1936	15′ 5″	2.37	14′ 8″	4.59	10′ 6″	2.78
1937	14′ 6″	8.32	13′ 10″	11.04	10′ 0″	4.43
*1938	16′ 3″	1.33	14′ 6″	5.14	11′ 0″	2.36
1939	16′ 8″	6.00	14′ 4″	8.92	10′ 8″	3.93
1940	— **	1.71	— **	4.74	— **	1.02
*1941	— **	0.63 ***	— **	0.63 ***	— **	0.63 ***
*1942	— **	4.65	— **	9.07	— **	4.87
1943	20′ 5″	4.39 ***	15′ 10″	4.39 ***	11′ 3″	4.39 ***

* Crops spoiled by May frosts. ** No Recorders to take measurements.
*** Crop recorded on block basis.

This plantation has been pruned throughout under accepted good plantation practice, but leader tipping and lateral cutting in the early years was much harder than is done to-day. Since thinning took place no cutting has been done which might reduce spread.

A plantation of Cox, Worcester and Superb bush trees on Type II rootstock planted in 1934–35 at 15′ x 15′ has been pruned more in accordance with modern ideas. No figures are available for crop, but spread measurements taken in the autumn of 1943 show the following result :—

TABLE II.

Variety.	Girth at 1′ above ground (in.).	Average height. (ft.)	Average spread. (ft.)
Worcester Pearmain ..	12.1″	10′ 2″	9′ 4″
Laxton's Superb	13.3″	12′ 5″	11′ 7″
Cox's Orange	11.5″	11′ 7″	11′ 7″

In eight years these trees have taken up a large proportion of their allotted space and some shoots met across the rows in 1943 when the trees carried heavy crops. The plantation has now been seeded down to Perennial Rye Grass and White Clover, but once the initial check is overcome it is expected the trees will continue to extend and thinning out will become inevitable at a much earlier period than in the plantation of Worcesters first mentioned. This more rapid spread of the mixed trees can justly be attributed to the pruning treatment, as growing conditions in both plantations are similar.

A third plantation consisting of alternate rows of Allington Pippin and Edward VII bush apples on Type II rootstock maintained in arable, was

planted at 15′ x 15′ in 1919–20. Spread measurements show that by 1937 the average spread of the Edward VII trees equalled the planting distance, *i.e.* 15′. Table III shows the increase in spread in following years when the trees by reason of more vigorous growth encroached upon the Allington row in one direction and grew into one another in the other.

In the winter of 1941 alternate trees were grubbed, and Table III shows how rapidly the trees extended, partly due to new growth and partly to the weighing out of branches by increased crops.

TABLE III.

Year.	Average branch spread in feet.	Crops per acre in tons.
1937	15′ 0″	1.01
1938	15′ 10″	1.78
1939	16′ 2″	1.78
1940	no record	2.55
1941	16′ 4″	nil*
1942	17′ 10″	9.87
1943	18′ 8″	4.59

*May frosts spoilt crops. Plantation thinned by half in winter.

The foregoing data show that, for the varieties mentioned, 15′ x 15′ planting is too close for good growing conditions at Long Ashton. Removal of alternate trees has left a plantation with trees approximately 21′ apart which, looking ahead, is still insufficient to allow of full unhampered development of the trees. To thin to 30′ apart, however, *i.e.* grub alternate rows and alternate trees in the remaining rows would probably result in too wide a spacing.

It seems reasonable to suggest, therefore, that under Long Ashton conditions, 24′ x 24′ is a suitable planting distance for bush apples on Type II rootstock. In view of the figures shown in Table I this could well apply to trees on other commercially favoured layered rootstocks with the exception of Type IX.

Trees on Type IX are worthy of consideration if " Fillers " are required in a plantation to increase returns in the early years. With permanent trees at 24′ apart, trees on Type IX could be employed as fillers at the 12′ interval, provided they are given a minimum of pruning, consistent with ability to carry a crop, and that they are grubbed *before* the permanent trees suffer from their presence. Under Long Ashton conditions and good cultural methods such " fillers " would have an approximate life of 10 years, by which time grubbing would be necessary to allow of easy mechanical management of the plantation.

II. Tree Thinning.

Tree thinning and its effect on crop production make interesting studies. Many growers when advised to thin an overcrowded plantation hesitate to do so because of possible loss of crop per acre. Even where cropping is lowered, however, this is only a temporary setback which is usually largely offset by saving in management and cultivation costs of all kinds and by improving the quality of the fruit.

The following figures showing crop per acre in tons relate to bush apple plantations in Worcestershire, all of which became overcrowded due to too close planting in the original layout. In each case thinning became imperative not only to maintain production of good quality fruit but also to enable cultural operations to be carried out with efficiency.

TABLE IV.

Year.	Plantation A.	Plantation B.	Plantation C.
1936	9.8	—	—
1937	4.4	—	—
1938	2.7	—	—
1939	5.2	—	8.8
1940	6.1	10.0	7.0
1941	3.2 *	18.6	6.6 *
1942	6.7	15.8 *	11.0
1943	5.2	21.6	10.2

* Plantation thinned by half in winter.

Plantation A. Six and a-half acres of Worcesters were established in 1904 by budding mixed Paradise, planted out at 11′ x 16′ (247 per acre) in a strawberry field. When first seen by the writer in 1935 the trees were carrying crops almost wholly on the tops and the close plant had led to the " cutting up " of the trees to prevent their interlacing.

Efficient spraying had become an impossibility; jobs such as grass cutting and manuring all had to be done by hand and the crop when picked had to be man-handled out to the roadways.

The grower could not secure his landlord's permission to thin the plantation until 1941–42, when cultural difficulties coupled with diminishing size and colour of much of the fruit, made the operation imperative. Alternate trees were removed and this at once eased all cultural operations. A tractor was able to enter the plantation for grass harrowing, cutting, fertilizer distribution and spraying (mobile) and harvesting costs were much reduced.

The removal of half the trees was followed by an application of 4 cwt. Nitro Chalk in late winter and a thinning out of old spur systems. Most trees have responded with new growth, and fruit quality has been much

improved. Fruit size returned, colour was excellent, and accessibility by sprayer has resulted in marked freedom from scab and pest damage.

Plantation B. This plantation was laid down in 1932 with 2-year-old trees of Laxton's Superb on Malling Type IX at 12′ x 9′, *i.e.* 403 trees per acre.

Cultivations have been consistently well done and regular dressings of potash were given annually until the war-time restrictions were imposed. The potash dressings were always accompanied by applications of nitrogen and phosphates. Crops began to be gathered in 1935. Meanwhile the trees grew quite strongly, and by 1939 showed signs of filling out their allotted space within a year or two.

By 1942 overcrowding was such that cultivation became almost impossible. The sprayer could no longer be drawn through the rows nor was there sufficient elbow room for the proper use of the spray lance.

In the winter of 1942–43 the number of trees was reduced almost by one half (145 trees to 77), and it is interesting to note that the 1943 crop was heavier than any gathered hitherto.

Pruning in recent years has been confined to an annual shortening of leaders, a thinning out or shortening of overcrowded shoots and the leaving of about half of the laterals full length.

Plantation C. Two-year-old trees of Cox on Type II were planted in 1931 at 12′ x 12′, *i.e.* 302 per acre. The history of development of this plantation is similar to that of the Superbs on Type IX and by 1941 overcrowding was acute. Scab became impossible to control. In the winter of 1941–42 alternate trees were removed providing easy access to the plantation once more. Here again it is interesting to note the crop per acre was not reduced by thinning.

Other examples of the effect of thinning on crop weights per acre are supplied by Tables I and III.

III. De-horning.

The practice of cutting back framework branches exceptionally hard, to restore vigour to established trees in a "standstill" condition, can result in a large measure of rejuvenation, as the following observations show :—

A block of 2-year-old trees of Cox on Type IX was planted in 1932 at 12′ x 9′, *i.e.* 403 per acre. Management was excellent and cropping began in 1935. Growth, however, was not so vigorous as on the Superb plantation on Type IX, mentioned above.

The trees grew well until 1939, by which time they showed signs of losing vigour. This weakening was not corrected by extra cultivations and heavier manuring. Good crops continued to be gathered, but fruit size diminished. In the winter of 1941, 50% of the leaders on all trees were fairly severely de-horned. Good new stout growth resulted and new limbs are being built into the trees.

De-horning increased fruit size. The weight per acre was also increased as is shown in Table V :—

TABLE V.

Year.	Tons per acre.
1939	6.8
1940	4.3
1941	6.2 **
1942	7.7
1943	8.0

** Trees de-horned in winter.

Discussion.

Plànting Distance. With the coming of peace, fruit growing in this country will certainly enter an era of fresh plantings to make up the leeway of war years. Of the many requirements to be considered by the planter, tree spacing has always been a problem. Planting has frequently been too close, and in few cases has the grower thinned overcrowded plantations in time to prevent considerable damage to the trees finally left standing, or indeed carried out any thinning at all.

In future it will be necessary to ensure maximum efficiency in every cultural operation and to use machinery to its fullest capacity. Ease of access to the mature plantation for all operations must be provided from the start. The optimum spacing for bush trees may be influenced by many factors, and it is impossible to be dogmatic. In order to make fullest use of land, and especially when an early return on capital is necessary, fillers on Type IX may be employed for, say, the first ten years*; alternatively, trees all on the same rootstock may be planted doubly thickly, with the very definite understanding that every other tree will be grubbed before it interferes with its permanent neighbour.

If this latter policy is followed it is essential (*a*) to plant on the square system, otherwise the alternate tree method will not leave a satisfactory plant after thinning, and (*b*) to plant at a spacing which, when the plantation is thinned, does not leave the trees too far apart.

Experience at Long Ashton suggests that a 24′ square plant (75 trees per acre) would be an economical spacing for bush apples of dessert varieties on a layered rootstock such as Malling Type II, for West Country conditions.

Fillers on Type IX could be used in the original plant at the 12′ interval, or trees on the same rootstock as the permanent plant could be introduced in the centre of each square, making a quincunx plant with the trees 24′ x 17′ at planting time.

Plantation Thinning, because of reducing the number of trees, is generally avoided by the grower. Expedients such as hard pruning, cutting-up or de-horning are often substituted, but, if trees are growing well, such practices are wasteful and prevent a plantation from attaining its full development and, it is suggested, its fullest cropping capacity.

Mention has been made of the many benefits which can accrue from

timely thinning out of overcrowded trees. These considerations will be still more important in the post-war period when production of high quality and high tonnages per acre will be imperative for the profitable marketing of crops.

The records of yields per acre, before and after the thinning out of trees, demonstrate that loss of crop subsequent to reducing the number of cropping trees per acre is small, and that thinning may in fact lead to heavier crops in two or three years.

Thinning out of trees in overcrowded plantations should be followed by intensifying cultural and manurial practices in order to get good leaf surface and new growth into the trees as quickly as possible, and pruning practices should aim at using new growth to the fullest advantage.

De-horning is no remedy for the overcrowded plantation. It is essentially an operation designed to rejuvenate unsatisfactory trees and coupled with suitable cultural methods, it can result in a striking renewal of young wood. In the plantation instanced de-horning proved well worth while and the branches left intact will in turn be " de-horned " at a future date.

THE EFFECT OF VARIOUS CONCENTRATIONS OF NAPHTHOXY-ACETIC ACID AND NAPHTHALENE-ACETIC ACID IN INHIBITING SHOOT DEVELOPMENT IN APPLE, SWEDE, CARROT AND POTATO.

By T. SWARBRICK.

It has already been established (1, 2) that while certain substances act as growth stimulators when used at low concentrations (0.001%) the same substances may actually inhibit growth when used at relatively high concentrations (1%).

Alpha-naphthalene-acetic acid (N.a.a.) has been the most commonly used growth substance in previous studies, mainly because it is so physiologically active. It is, however, difficult to synthesise, therefore, it is costly to produce. A new substance, beta-naphthoxy-acetic acid (N.o.a.) has been introduced by Zimmerman and Hitchcock which is easy to produce and in certain directions is even more physiologically active than N.a.a.

The main object of these preliminary studies is to compare the effectiveness of these two substances in the inhibition of shoot growth.

Experiments on Apple.

The first trial was an attempt to determine the effect of a single application of these substances to the ends of one-year-old apple shoots. A large number of more or less identical shoots were selected and tagged on large vigorous Crawley Beauty trees on a strong rootstock growing at Long Ashton. The shoots were then pruned by removing about one-third of their total length, leaving a good lateral bud in the new terminal position. At this time there was no sign of bud break. A minimum of ten shoots per treatment was used. The following treatments were applied to the cut exposed ends of the shoots on April 13th, 1943 :—

1. Control. No further treatment.
2. Methylated Spirits (90—95%).
3. 1% Naphthalene-acetic acid in Methylated Spirits.
4. 1% Naphthalene-acetic acid in Lanolin.
5. 1% Naphthoxy-acetic acid in Methylated Spirits.
6. 1% Naphthoxy-acetic acid in Lanolin.

It was found that however careful one was, some of the alcoholic solutions crept down the shoot and completely enveloped the terminal bud.

The following notes were made on May 25th, 1943, which was the petal fall stage for these trees—Crawley Beauty being a very late flowering sort :—

1. *Control.* All buds developing normally. The terminal buds on each shoot had made some extension growth.
2. *Methylated Spirits.* Most of the buds growing normally. No evidence of any deleterious effects from the application of the Methylated Spirits.

3. 1% *N.a.a. in Methylated Spirits.* All buds on the 1942 growths still practically dormant. Some bud swelling but no sign of bud break. The spurs, etc., on the 1941 growths were developing normally, *i.e.* had flowered and were now at petal fall stage.
4. 1% *N.a.a. in Lanolin.* The top two buds have remained dormant. The lower buds on the 1942 growths were beginning to grow out normally.
5. 1% *N.o.a. in Methylated Spirits.* Only the top bud remains dormant. The lower ones are showing marked signs of development but are very much behind buds occupying a similar position on the controls.
6. 1% *N.o.a. in Lanolin.* Top bud only dormant and even this is "swelling." The lower buds are almost at the same stage of development as the controls.

No further observations were made until the end of the growing season. At this time it was found that the effects noted earlier in the season had been maintained. The control shoots had made the normal response to pruning. The shoots treated with methylated spirits only were substantially the same as the controls. Of the shoots treated with 1% N.a.a. either in methylated spirits or in lanolin, many had produced no new shoot growths, while the others had produced one short stunted growth from the "terminal" bud. The contrast between these shoots and the controls was very marked indeed. The shoots treated with N.o.a. in methylated spirits or in lanolin had made more growth than those treated with N.a.a. but far less than the controls.

In another trial of the same kind, using shoots which had not been cut back, so that they retained their normal terminal bud, similar results were obtained. In these cases the shoots treated with N.a.a. and to a less extent those treated with N.o.a. developed very strong autumn colorations very early in the season. The untreated shoots developed normally but the treated ones had made shoot growths of about two to three inches long. The growth was terminated by a very large flower bud. The subterminal buds had also developed into large flower buds. By August 20th, the leaves of these treated shoots were a brilliant red bronze colour. The leaves were thick and were retained longer than those on the control shoots.

While these experiments must be regarded as preliminary in character, they have given a positive result. N.a.a., and to a less extent N.o.a., when applied either as a 1% solution in alcohol or in lanolin, retarded shoot growth over a complete season. This effect was apparent over a considerable length of the shoot because sub-lateral buds did not develop into shoots, which would have been the case had the terminal buds been merely removed. Furthermore, both these substances have had a profound effect upon local physiology. Any leaves produced within about a foot of the treated area developed pronounced and vivid autumn colourations very early in the season. These brilliantly coloured leaves remained on the tree until after the normal time of leaf fall.

It would seem, therefore, that a high concentration of N.a.a. was effective in retarding and in some cases preventing the development of buds into shoots.

Experiments on Swedes and Carrots.

The effect of a high concentration of N.o.a. and N.a.a. upon the develop-

ment of dormant buds in the Swede and Carrot was determined in spring 1943 as follows :—

Lanolin Mixtures containing 0.25, 0.5 and 1.0% N.o.a. and N.a.a. were made up in the usual way.

On March 24th, 1943, a number of swedes and carrots were divided into two groups. One group of each was used as controls by smearing over their crowns with lanolin. This was achieved by the simple process of smearing the palm of the hand and rubbing each carrot or swede. In this way a thin film or deposit of the lanolin was distributed over the entire surface. The treated plants were smeared in the same way, but with lanolin containing 1% N.o.a. or 1% N.a.a. respectively. The roots were then planted in soil under the bench of a heated greenhouse, and the whole well watered. Conditions were therefore very favourable to growth.

By April 3rd, that is within 10 days, the untreated swedes had produced numerous shoots, some as much as 2—3 inches long, many of which were developing leaves, whereas there was no sign of shoot growth on the plants treated with 1% N.o.a. or 1% N.a.a. in lanolin. The plants treated with lanolin only grew away normally producing an abundance of shoots and roots. The plants treated with a 1% preparation of N.o.a. and N.a.a. in lanolin produced neither shoots nor roots. The failure to produce roots was not anticipated, but the high concentration of N.o.a. and N.a.a., when applied to the crown, effectively prevented both shoot and root growth even under the most favourable conditions. The roots shrivelled and gradually disintegrated.

Experiments on Potatoes.

The problem of preventing sprouting in potatoes is of great economic importance in war time when it is necessary to keep a reserve of old potatoes until the new ones are ready for digging. It was considered desirable to try the effect of both N.o.a. and N.a.a. at high concentrations upon the delaying of sprout formation in the potato.

On April 9th, 1943, some 200 well-shaped medium-sized potatoes were selected from the bulk of a large consignment of Red King seed potatoes direct from Scotland. In order to make the treatments even more uniform all the potatoes were washed in tap water and allowed to dry at room temperature. Ten groups of 20 potatoes were chosen at random and subjected to the following treatments :—

1. Control—No further treatment.
2. Potatoes washed for one minute in a 0.5% dispersion of N.a.a. in tap water.
3. As for treatment 2 except that the 0.25% dispersion was used.
4. As for treatment 2 except that a 0.125% dispersion was used.
5. Potatoes were rubbed all over with lanolin containing 1% N.a.a. Particular care was taken to cover the " eyes " but the smallest amount was used.
6. As for treatment 2 except that a 0.5% dispersion of N.o.a. was used.
7. As for treatment 3 except that 0.25% dispersion of N.o.a. was used.
8. As for treatment 4 except that 0.12% dispersion of N.o.a. was used.
9. As for treatment 5 except that a 1% N.o.a. in lanolin was used.
10. Control.

After treatment the potatoes were put into shallow seed boxes and placed in the heated greenhouse over the week-end. On Monday, April 12th, fifteen potatoes of each treatment were planted in the normal way in the garden at Long Ashton. The remaining five potatoes of each treatment were planted in potting compost in a cool greenhouse.

Results.

1. *Plants in Greenhouse.* Of the potatoes planted in the greenhouse the controls began to sprout in a few days. In about a week to ten days these potatoes had developed a sprout from every eye and were showing very vigorous shoot growth. The 0.125, 0.25 or 0.5% N.o.a. did not exercise much delaying or retarding action on sprout development. Of the 1% in lanolin treatments the N.o.a. retarded but did not completely inhibit bud development, whereas the 1% N.a.a. did completely inhibit bud growth. The potatoes treated with 1% N.a.a. in lanolin slowly shrivelled and dried up without ever producing sprouts.

2. *Plants in Garden.* These potatoes were planted on Monday, April 12th, 1943. At the time of planting no sprouts were showing on any sets. By May 20th all the control plants—two groups of fifteen potatoes—were showing above ground. Of the fifteen plants treated with 0.125% N.o.a. two were showing, of the 0.25% four were showing, of the 0.5% two were showing, and of the 1% in lanolin four were showing. No plants were showing from any of the N.a.a. treatments.

On June 22nd, that is two months after planting, a further detailed examination was carried out of the potatoes growing in the garden. The results are listed in Table I.

The general result is that under greenhouse conditions, which of course are abnormal for the storage of potatoes, only the 1% N.a.a. inhibited bud growth. Any lower concentration retarded development but did not inhibit it. 1% N.o.a. greatly retarded bud growth but did not inhibit it, whereas any lower concentration had little or no effect. Under garden conditions—which are normal—the effects were more pronounced. A concentration of 0.5% N.a.a. completely inhibited any shoot growth, while concentrations as low as 0.125% retarded it by as much as three weeks to a month. N.o.a. proved to be much less effective than N.a.a.

On June 22nd a number of the potatoes were dug in order to observe their underground development. The control plants and the N.o.a. treated plants were apparently developing normally but the N.a.a. treated sets were quite abnormal. Most of the 1% and 0.5% treated sets were recovered. Without exception these were still sound and very firm in texture. They were all severely infested with wireworms and slugs, some of them almost completely hollowed out, but that part which remained was perfectly sound healthy potato tissue. In a few cases these potatoes, which it will be remembered had failed to produce shoots, had produced roots from the base of the potato eyes. One such typical plant was photographed (*Fig.* 1). All the treated potatoes showed a marked proliferation of the lenticels.

Conclusions.

These observations made during 1943 on apples, swedes, carrots and

potatoes show quite clearly that shoot development may be delayed or even completely inhibited by the use of a solution of N.a.a. Of the two methods tried on the vegetables, namely dipping in an aqueous solution and smearing with lanolin, the former is by far the easier and cleaner. From the economic standpoint the dipping method offers distinct advantages in that it could be used as a continuous process.

It is pointed out that the trials reported here are preliminary in character. It is obvious that other substances may be equally or even more effective in delaying or inhibiting bud growth. It is hoped to be able to extend these investigation in 1944.

REFERENCES.

(1) Denny, F. E. Contributions Boyce Thompson Institute. Vol. 12, p. 387, 1942.

(2) Zimmerman, P. W. and Hitchcock, A. E. Cont. Boyce Thompson Institute. Vol. 11, p. 1, 1941.

Fig. 1. Showing potato treated with 1% N.a.a. in water, after having been in the ground for 12 weeks after treatment. Note complete absence of shoots and the root development from the original tuber.

TABLE I.

Results with Potatoes.

Treated April 9. Planted April 12.

Site.	Controls.	Treated with N.A.A.				Treated N.O.A.			
		1% in lanolin.	0.5% in water.	0.25% in water.	0.125% in water.	1% in lanolin.	0.5% in water.	0.25% in water.	0.125% in water.
In greenhouse (5 per treatment)	Normal	Growth inhibited : tubers shrivelled	Little retardation			Growth retarded but not inhibited	Little retardation		
In garden (15 per treatment) :									
Plants showing									
May 20 :—	15	0	0	0	0	4	2	4	2
June 22 :—	All growing strongly	2 very small weak plants: tubers still sound and firm	0 plants growing : tubers still sound and firm	6 very weak late plants	7 very weak late plants	All growing but half normal size	All growing : some vigorous some weak	All growing fairly strongly	All growing quite strongly

PROGRESS REPORT ON THE USE OF NAPHTHOXY-ACETIC ACID TO INCREASE THE FRUIT SET OF THE STRAWBERRY VARIETY TARDIVE DE LEOPOLD.

By T. SWARBRICK.

Material and Methods.

In a previous report it was shown that certain growth substances increased the fruit set of certain self sterile varieties of Strawberry. In spring 1943 a field trial was carried out in Herefordshire using only naphthoxy-acetic acid which was found in 1942 to be more effective in this respect than was naphthalene-acetic acid.

The material available was a large block of 3-year-old plants laid out in alternate strips of six rows of Tardive and six rows of Sovereign, to act as pollinator. It was known that the yield of Tardive was low owing to the lack of adequate pollination. As is usual with a three or four-year-old strawberry plot the run of plants was very variable. Since this was intended to be a field trial, four places were chosen where the plants of Tardive were reasonably good. In these four areas four adjoining rows were taken and uniform lengths of twenty-five yards were marked. In this way eight double row plots of Tardive were obtained. One row of each plot was treated ; the adjoining row was used as control. No record was made of missing plants, poor plants, etc., although it should be pointed out that there was considerable variation in this respect.

Naphthoxyacetic acid in water at 20 p.p.m. was applied as a drenching spray from a knapsack sprayer on May 26th, 1943. At this time the Tardives were in full flower, and the Sovereigns practically over. Only one application was made. Picking of the Tardives began on June 17th and extended to July 9th. By the kind co-operation of the grower a record of yield was obtained at the time of each picking. From this yield per twenty-five yards run the yield per acre has been calculated, assuming rows to be a yard apart. For the convenience of growers this calculated yield per acre is used as the basis of discussion. No attempt is made in this preliminary report to discuss such details as effect of treatment upon distribution of crop over the season. The important point to establish is the possibility of increasing, by a spray treatment, the crop yield of the variety Tardive de Leopold.

Results.

The calculated yield per acre in lb. is given for each of the control and treated plots in Table I. Statistical requirements have been met by the analysis of variance method. The data show that mean yield has been increased by 940 lb. per acre by spraying. As the difference required for significance is 750 lb. the increase in yield is proved to be due to the treatment. From the grower's standpoint an increased yield of nearly 9 cwts. per acre must be regarded as important.

It may be pointed out that owing to favourable weather in 1943 the yield of Tardives in this plantation was above the general average. The later pickings in particular were very much better than usual.

General observations made at picking time suggest that fruit from the treated plots was a much better and " cleaner " sample than from the controls. Detailed examinations showed that in spite of an incomplete set of seeds on the treated fruits, their development was practically normal as regards size and shape. This suggests that the naphthoxy-acetic acid has encouraged the tissue development in spite of the lack of complete pollination. The interpretation is strengthened by the fact that the number of fruits harvested is not significantly greater from the treated plots than from the untreated. Increase in average size per fruit must have been largely responsible for the increased yield due to treatment. This work is being continued more particularly with a view to trying new and more effective substances.

Table showing Yield in lb. per Acre calculated from Plot Yield.

Unit.	Treated.	Control.
1	8422	6402
2	5977	4567
3	6249	4891
4	6182	6669
5	5415	5415
6	6365	4710
7	6694	6465
8	6892	5577
Mean	6527	5587
Difference in favour of treatment		940 lb. per acre
Signif. difference required by Analysis of variance method		750 lb.

EXPERIMENTS IN MINERAL NUTRITION. 1.

THE VISUAL SYMPTOMS OF MINERAL DEFICIENCIES IN VEGETABLES AND CEREALS GROWN IN SAND CULTURES.

PROGRESS REPORT No. 1, 1943.

By E. J. HEWITT.

INTRODUCTORY.

In continuation of the work of Professor Wallace on the diagnosis of mineral deficiencies in plants by visual symptoms (3), twenty-three crops were grown in sand culture during 1943 for the systematic study of mineral deficiency symptoms produced under conditions of controlled nutrient supply. The principal aims of the 1943 programme were (*a*) the extension and confirmation of the present records of typical deficiency symptoms, (*b*) the determination of the effects of added sodium sulphate and sodium chloride with special reference to the use of salt as a fertiliser, (*c*) the study of the problems involved in maintaining large-scale deficiency culture experiments using a wide range of crops, (*d*) the development of a satisfactory and economical technique for the study of trace element deficiencies.

In the investigation of (*d*), two methods of experiment were employed. In the one, rainwater, unwashed sand, and chemicals up to the A.R. grade of purity were used. In the other, distilled water, unwashed sand, and highly purified or A.R. grade chemicals were employed. The experimental data and results relating to the two series of experiments are described separately below.

THE RAINWATER SERIES.

Materials and Methods.

Pots and Sand.

Ten-inch clean, unglazed, waxed flower pots were used for all crops except lettuce and radish, which were grown in six-inch pots. Each pot was filled with 9 kilos of unwashed, pure quartz sand (2.5k. for the 6-inch pots). An analysis showed silica 99.9% ; Fe 360 p.p.m. (*i.e.* 0.05% as Fe_2O_3) ; Mn 0.28 p.p.m. ; B 3.5 p.p.m. ; Ca not detected.

The pots were arranged in a large glasshouse in groups of five per treatment.

Rainwater.

The rainwater was collected from the glass roof in tanks painted with

black liquid bitumen (ash 0.1%). An analysis of the rainwater sampled in May showed Fe 0.03 (0.055) p.p.m.; Mn 0.01 (0.01) p.p.m.; Cu 0.01 (0.015) p.p.m.; Zn 0.39 (0.10) p.p.m. (The figures in brackets refer to water collected from the roof during the rain.)

Nutrient Solutions.

These solutions were made up using re-crystallised grade KNO_3, $NaH_2PO_4.2H_2O$, $MgSO_4$, anhydrous Ca $(NO_3)_2$ and Analar $FeCl_3.6H_2O$. Two types of nutrient solutions were in general use. Type 1 solutions contained calcium and potassium in equal proportions, and Type 2 had twice the proportion of calcium to potassium. Type 2 was used for all crops except tomato (for the first 8 weeks after potting) and potato.

For the nutrient solution used for trace element deficiencies Analar KNO_3 and $MgSO_4.7H_2O$ were used. One litre of a supplementary trace elements solution, made up of B 0.5 p.p.m., Mn 0.3 p.p.m. and Cu 0.1 p.p.m., was given once a week. No additional zinc was given, as it occurred to the extent of 0.4 p.p.m. in the rainwater. At the end of the season the Zn content has risen to 1.6 p.p.m., but no harmful effects were observed. No additional molybdenum was given.

The concentrations, in p.p.m., of the various elements in the complete nutrient solution as applied were as follows (Type 2 concentrations in brackets): N 142, K 135 (81), P 41, Ca 134 (164), Mg 40, Fe 14, S 52, Cl 26, Na 30, B 0.5, Mn 0.3, Cu 0.1.

In making up the nutrient solutions for specific deficiencies the following salts, in equivalent concentrations, were used as substitutes: omitting nitrogen, $CaSO_4.2H_2O$ and K_2SO_4; omitting potassium or calcium, $NaNO_3$; omitting phosphorus or magnesium, $Na_2SO_4.10H_2O$; omitting sulphur, $MgCl_2.6H_2O$; omitting iron, NaCl.

The pH values of the nutrient solutions were low, owing to the use of $FeCl_3$. See Table I.

TABLE I.

pH Values of Nutrient Solutions (ready for application).

Complete Nutrient ..	3.58	Omitting Ca	3.51
Omitting N	3.55	,, Mg	3.68
,, K	3.59	,, Fe	5.03
,, P	3.49	Rainwater July	6.03
		,, Oct.	6.24

Crops grown and treatments given.

A summary of all the crops and treatments included in the rainwater series is given in Table II.

TABLE II.

Crops grown and Treatments given.

Crop and Variety.	Treatments in addition to complete nutrient treatment.	
	Omissions.	Additions.
Wheat .. Red Marvel	N, K, P, Ca, Mg	
Barley .. Plumage Archer	N, K, P, Ca, Mg, trace elements	
Maize.. .. Golden Bantam	Mg	NaCl
Cabbage .. Improved Winningstadt ..	P.Mg	Na_2SO_4, NaCl
Cauliflower .. Majestic	N, K, P, Ca, Mg, S, Fe, B, Mn	ditto
Sprouts .. Rous Lench		ditto
Kale .. Marrowstem Green ..	Ca (at pH 3.5 and 6.5), S, B	ditto
Rape .. Black	P	ditto
Turnip .. Improved EarlyWhiteStone	P, Ca, Mg, S	ditto
Swede .. Purple Top	P, trace elements	ditto
Lettuce .. All-Year-Round	N, K, P, Ca, Mg	
Radish ..	N, K, P, Ca, Mg	
Carrot .. Early Model		ditto
Celery .. Monarch White	B	
Sugar Beet ..	N, K, P, Ca, Mg, trace elements	
Garden Beet Detroit Red Globe ..	Mg	ditto
Broad Bean .. Exhibition Longpod ..	N, K, P, Ca, Mg	
Dwarf Bean .. French Masterpiece ..	Mg	
Red Clover .. Dorset Marlgrass	N, K, P, Ca, Mg	
Flax .. Liral Prince	N, K, P, Ca, Mg, trace elements	
Leek ..	N, K, P, Ca, Mg	
Tomato .. Market King	N, K, P, Ca, Mg, S, Fe, B, Mg	Na_2SO_4, NaCl
Potato .. Majestic	N, K, P, Ca, Mg, B	

Sowing and transplanting.

Twenty-four hours before sowing, all pots were given three litres of complete nutrient solution without trace elements (and omitting iron in iron-deficiency cultures) to enable the plants to make some growth before deficiency symptoms supervened.

Tomatoes for the " Major Elements Series " were sown in sterilised compost on February 22, and transplanted on April 29. Tomatoes and brassicae for the trace-element series were sown in sand on April 3 and transplanted on April 30.

Cauliflowers, cabbage, kale, rape and sprouts were sown in sterilised compost on March 29 and transplanted on April 29. Celery was sown in sand on April 3 and transplanted on May 13, three per pot. Sugar beet was sown on April 4 in sand and transplanted (1 per pot) on April 29.

Stock seed potato tubers were sprouted with two shoots near the apex and planted 6 in. deep.

Lettuce plants were transplanted on May 26 when about $1\frac{1}{2}$ in. high. Radish was sown following the lettuce on August 3 and leeks transplanted on July 7 following wheat, which was too badly attacked by mildew to be used for observations. Barley was sown on June 10 and all remaining crops on April 29.

A second series of calcium deficient cultures was started on July 29 in which the sand was pretreated with calcium deficient nutrient in place of

complete nutrient; the symptoms described below below refer to this series unless otherwise stated.

Watering.

Nutrient solutions were diluted ready for use just before application. The pots were given 500 to 1,000 ml., according to requirements, about four times a week, and rainwater only at other times, and 500—1,000 mls. of the supplementary trace-elements solution weekly. Once in every four weeks all cultures were leached with 2 litres of rainwater per pot to wash out accumulated salts. As a result of the growth of the plants the pH of the nutrients in the sand became markedly changed, as is seen by comparing the figures for the nutrient solutions in Table IV with those for the leachates given in Table III.

TABLE III.

pH VALUES OF LEACHATES FROM POT CULTURES.

Crops and date	Leaching solution	Culture treatment.									
		Complete Nutrient	Omitting.								
			N	K	P	Ca Series 1	Ca Series 2	Mg	Fe	S	Minor Element
Cauliflower ... 9.7.43	Appropriate nutrient solutions	7.56	6.93	7.66	7.46	7.92		7.62	7.88		
Cauliflower ... 16.7.43	Rainwater of pH 6.03	8.42	7.84	8.30	8.34	8.50		8.42	8.10	8.40	
Sugar beet ... 29.9.43	Ditto	7.48	6.78	7.42	7.38	7.26	7.14	7.56			7.18
Leek ... 30.9.43	Ditto	7.39	6.91	7.64	7.20	7,69		7.40			
Red Clover ... 1.10.43	Appropriate nutrient solutions	8.00	7.02	8.05	8.00	8.37	8.20	8.14			

Pest and Disease Control.

Attacks by aphides became sufficiently widespread by the middle of July to require control by spraying. Brassicae were sprayed with 0.1% nicotine in water with sulphonated lorol (1 oz. per 10 gall.) as spreader, as this was free of K, Ca and Mg. Swedes showed a temporary marginal chlorosis after spraying. For spraying trace element cultures methyl cellulose ester was used, as being less likely to contain these elements.

Attacks by Mildew on brassicae were controlled by spraying with "Bouisol," using sulphonated lorol as an additional spreader. The trace-element cultures were sprayed with Bouisol washed free of lye and made up with methyl cellulose ester as a spreader.

Clover was sprayed with a variety of fungicide-spreader mixtures to find which was least damaging. The following combinations were tried :—

1. Microsul (1 fl. oz. per gall. water) on Complete Nutrient culture.
2. Microsul plus sulphonated lorol on Complete Nutrient culture.
3. Bouisol plus methyl cellulose on N-deficient but healthy culture.

4. Microsul plus methyl cellulose on N-deficient but healthy culture.
5. Microsul (1 fl. oz. per gall. water) on Mg deficient culture.
6. Microsul plus sulphonated lorol on Mg deficient culture.

The results obtained were: Nos. 2 and 6 gave fair control in 2—3 days without damage; Nos. 1, 4 and 5 gave little or no control; No. 3 showed signs of damage.

Systematic Description of Typical Symptoms.

Many symptoms observed during this investigation have been previously described (3) and are omitted from this report unless they are of some special interest. The number of days entered in the left-hand column shows the period at the end of which the deficiency symptoms were evident. A statement followed by (T) indicates that the record is of a tentative character, requiring confirmation.

Maize.

With *magnesium* omitted, the older leaves show blotchy intervenal orange-yellow tints and reddening of tips.

Cabbage.

Omissions.	
Phosphorus .. .. (35 days)	Growth slow, squat, somewhat rosette, not hearting. Foliage dull green; old leaves tinted dull purple and bronze.
Magnesium .. .. (42 days)	Old leaves with pale yellow-green mottling and intervenal chlorosis starting at margins; red tints developing later at margins and in chlorotic areas.

Cauliflower.

Omissions.	
Potassium .. .. (35 days)	Growth stunted. Leaves showing grey and white marginal spotting followed by marginal and intervenal scorching; leaf tips down-curved, margins inrolled. Finally yellow and orange tints next to scorched areas; old leaves completely scorched. Flowering premature (July 20) followed by bolting on Aug. 2.
Boron .. .. (63 days)	Faint orange tinting of margins at tips of old leaves; slight twisting of young petioles and leaves at midribs; roughening of petioles and stem, and browning of pith in region of leaf attachment. Curds browning in patches.

Marrowstem Kale.

Omissions.	Growth.	Leaves.
Calcium .. .. (at pH 3.5)	Slow, weak; growing points weak	Young leaves slightly mottled faint white marginal rims, disappearing later. (T.)
Calcium .. .. (at pH 6.5)	Slow, weak; growing points sometimes dying. (T.)	Slight mottling.
Sulphur		Old leaves somewhat pale yellow green.
Boron .. .. (14 weeks)	Slightly distorted; one growing point aborted and was replaced by lateral buds.	One plant had old leaves with faint marginal mottling near rims and distorted leaf margins. (T.) Cavities in pith in region of leaf attachment.

Turnip.

Omissions.	Growth.	Leaves.
Phosphorus .. (45 days)	Slow, restricted. Roots fail to swell.	Small; dull green, showing dull purple or bronze tints with age, mainly at margins; oldest leaves show some yellowing, occasionally slight scorching.
Calcium	Some distortion of growing points	Young leaves rather pale, faintly mottled. (T.)
Sulphur		Old leaves pale green with white chlorotic areas between veins. (T.)

Lettuce.

Omissions.	Growth.	Leaves.
Nitrogen .. .. (21 days)	Greatly restricted, plants very weak.	Very small, pale yellow green.
Potassium .. .. (28 days)		Old leaves with marginal chlorosis followed by brown scorch; later scorching progressing, intervenally.
Phosphorus .. (42 days)	Restricted.	Small, rather pale, lustreless green, yellow and bronze tints.
Calcium .. .. (35 days)		Cupped and puckered; marginal necrotic spots; early Botrytis infection of young leaves.* (T.)
Magnesium .. (40 days)		Old leaves intervenal chlorotic mottling.

* *Note.*—Botrytis infection appeared on the complete nutrient, potassium deficient and magnesium deficient cultures more than a week later than in the calcium deficient cultures and was far less severe. The nitrogen deficient and phosphate deficient cultures remained clean.

Radish.

(This crop followed lettuce without further pretreatment of sand).

Omissions.	Growth.	Leaves.
Nitrogen	Very slow, restricted, no swelling of roots.	Very small, pale green with yellow tints and red petioles.
Potassium		Old leaves rather dark green, curling back, margins paling, then scorching; trace of intervenal chlorosis.
Phosphorus ..		Small, possibly less serrated than normal, dull green with bronze tints at margins.
Calcium	No definite symptoms observed.	
Magnesium ..		Old leaves with conspicuous yellow or orange tints; often wide orange margin.

Celery.

With boron omitted, growth was greatly restricted, weak and bushy. Death of the growing points of young leaves was frequently followed by the production of secondary growing points. The leaves were distorted, dark green with yellow blotching; the petioles twisted and cracked across the vascular bundles allowing the epidermal tissue to curl up to form a rough surface. Symptoms were evident in 21 days.

The plants respinded in 7 days to a one litre application of boron at 0.5 p.p.m.

Sugar Beet.

Omission.	Growth.	Leaves.
Boron and Trace Elements .. .. (20 weeks)		Leaves small and rounded. Pink tints at base of young petioles; old petioles tend to be elongated. (T.)

Broad Bean.

Omissions.	Growth.	Leaves.	Fruits.
Nitrogen .. (35 days)	Thin, dwarfed.	Small, narrow, pale yellow green, yellowing and falling prematurely.	Pods, few, beans small.
Phosphorus .. (56 days)	Thin, dwarfed, erect.	Narrow, leaflets pointing acutely upwards, lustreless pale green; yellowing at base and falling prematurely. Old leaves infected with *Cercospora Fabae*	Pods greatly reduced, beans very small.
Calcium ..	Weak growing points	Paling of tip leaves.	Pods and fruit large. See Note A below.
Magnesium .. (70 days)		Lower leaves paling and yellowing intervenally while margins remain green, upper leaves affected eventually.	Pods and fruits normal.

Note A. Beans taken from the pods produced in the above deficiency series were germinated in sand compost and soil with rainwater only. Those from the calcium deficient series in sand gave thin, very tall straggling plants with defective growing points, while the stems failed to stand up. The leaves produced were narrow, pale, often distorted and with black marginal puckering. The remaining seeds developed normally.

Note B. The weights and number of beans produced are given in Table IV.

TABLE IV.

Weights and Numbers of Beans in Sand Culture Experiments.

Treatment.	No. of Plants.	No. of Beans.	Total Wt. Beans (gm)	Av. No. per Plant.	Av. Wt. per Plant.	Av. Wt. of Bean.
Complete Nutrient ..	10	265	331	26.5	33.1	1.25
Omitting N ..	8	81	75	10.1	9.4	0.93
,, K ..	9	55	44	6.1	4.9	0.80
,, P ..	10	24	24	2.4	2.4	1.00
,, Ca ..	9	199	356	22.1	29.6	1.79
,, Mg ..	9	201	309	22.3	34.3	1.54

Dwarf Beans.

With magnesium omitted, the older leaves first show light yellow-green intervenal mottling becoming yellow and followed by considerabble brown necrotic spotting. Old leaves shrivel and fall prematurely (symptoms evident in 45 days).

Red Clover.

Omissions.	Growth.	Leaves.
Nitrogen ..	At first, weak and slow.	Small pale green (recovering on nodulation in 6–7 weeks).
Potassium .. (35 days)		Older leaves in early summer dark green with light brown spotting just inside margin leading to brown marginal scorch with inrolled margin ; later with light brown hatching either between veins at margins or along midrib, followed by severe scorch. (Symptoms much reduced in second growth after cutting back in late August)
Phosphorus .. (50 days)	Thin, restricted.	Small, dark green, later pale yellow green with scattered dark purplish brown spots, frequently withering. Petioles red-brown, often wilting. Symptoms persist in weak second growth.
Calcium ..		Upper leaves pale green ; unfolding delayed slightly distorted. Some spotting on tip leaves resembling K deficiency but less regular and not persistent (T).
Magnesium .. (50 days)		Old leaves paling, becoming yellow green and yellow at margins and intervenally with necrosis; margins later turning red-brown with occasional scorching. Symptoms reduced in second growth.

Flax.

Omissions.	Growth.	Roots.	Leaves.	Stems.	Fruiting.
Nitrogen .. (28 days)	Very thin, dwarfed.		Small, narrow, pointing upwards, green at top, yellow at base, falling prematurely.	Pale green, pale red at base, lateral branching suppressed entirely.	Greatly reduced.
Potassium .. (35 days)	Bushy.		Lower leaves with brown " tip burn " scorching without chlorosis.	Internodes shortened.	
Phosphorus .. (42 days)	Thin.	Browning slightly	Narrow, pointing upwards, dull blue-green at tip, yellowing at base, falling prematurely.	Yellow green with slight purple tinge at base ; lateral branching practically suppressed.	Much reduced.
Calcium .. (21 days)	Very bushy growing points often defective.	Brown in parts.	Tip leaves and bracts pale yellow green.	Much lateral branching. Pedicels often wilted and eventually shrivelled.	Many flower buds blind; profuse floral branching after death of primary growing points(T).

Flax—*continued.*

Omissions.	Growth.	Roots.	Leaves.	Stems.	Fruiting.
Magnesium ..	Bushy, slightly stunted.		Lower leaves yellow : tips eventually scorching with adjoining yellow zone : leaf fall premature.		Slightly reduced.
Trace Elements ..	No symptoms observed				

Note.—A flax series grown in the open in an attempt to avoid drawing showed similar symptoms except that the K deficient plants were more stunted. Rust infected all except the N- and P- deficient cultures.

Leek

(following wheat without further pretreatment).

All series, trace tip die-back ; with nitrogen omitted, leaves small and pale yellow green ; with phosphorus omitted, leaves dark green ; with magnesium omitted, leaves slightly pale green.

Tomato.

Omissions.	Growth.	Leaves.	Fruit.
Nitrogen .. (35 days)	Weak, thin, dwarfed.	Very small, stiff, pale yellow green ; old leaves yellow with purple veins, prematurely shed.	Crop much reduced. Fruits small and sweet.
Potassium .. (50 days)	Stunted.	Small, dark green ; lower leaves grey at margins, then intervenally ; tips and margins scorching and curling upwards ; leaves convex ; finally scorching severely at top of plant.	Ripening unevenly, giving blotchy appearance. Flavour sub-acid and insipid.
Phosphorus .. (35 days)	Thin, spindly, dwarfed.	Mature leaves small, leaflets down-curled, dull bluish green upper surface, older leaves purpling with scorched areas ; oldest leaves yellow with purple veins ; prematurely shed.	Crop reduced. Fruit small, acid.
Calcium .. (50 days)		Young leaves with yellow orange and purple tints in centre of tip leaflets, spreading to side leaflets ; finally collapsing and withering. Roots browning, especially the young adventitious ones (T).	Trusses failing to set, withering at distal end. Fruit tending to ripen less rapidly at blossom end.
Magnesium .. (42 days)	Reduced.	Old leaves with intervenal yellowing spreading from margins, with necrosis and eventually chlorotic and withering. Chlorosis spreading up plant to young leaves,.	Medium size, usually with pronounced "green back" giving hard yellow or orange region at base of mature fruit.
Iron ..		No definite symptoms appeared.	Some tendency to show "green back."
Boron ..		Petioles of upper and middle leaves curling down with some paling at base of leaflets and occasional marginal scorching and necrotic areas with purpling underneath or at margins (T).	Crops normal.

Potato.

Omissions.	Growth.	Leaves.	Flowers.	Tubers.
Phosphorus .. (56 days)	Thin, dwarfed.	Pale; light brown scorch commencing intervenally and extending to upcurled margins. Old leaves yellow and shed prematurely.	Reduced	Few and small.
Calcium ..	Bushy, branched from base. Haulms rather slender.	Tip leaves slightly pale.		Very numerous, small, irregular, dark brown often soft; interior brown.
Magnesium .. (56 days)	Slightly stunted.	Basal leaves with intervenal yellowing within green margins, followed by central brown necrotic areas and yellow margins. Old leaves prematurely shed.		Reduced in size and numbers.
Boron ..		Tip leaflets pale between veins at tips, tending to tip scorch (T).		Large, some split at growing point end.

Note A.—The tuber yields are given in Table V.

TABLE V.

HARVEST OF TUBERS.

Treatment.	Number of Tubers.	Total Wt. (gm).	Av. per tuber (gm).	Size range (inches).
Complete nutrient ..	60	4095	68.2	1–5
Omitting N. ..	25	535	21.4	1–2.5
,, K. ..	39	1195	33.2	1–3.5
,, P. ..	49	1255	25.6	1–2.5
,, Ca. ..	595	2500	4.2	mainly under 1
,, Mg. ..	61	1720	28.2	1–2.5
,, B. ..	64	4900	76.6	1–5

Note on cultures not showing deficiency symptoms.

Owing apparently to high retention of calcium in the sand or pots after pretreatment with complete nutrient, very few of the original calcium deficient series showed symptoms except the potato (in the tubers) and, to a slight degree, flax. Calcium-deficient lettuce was apparently more susceptible to *Botrytis*. In the second series, in which no calcium was given in the pretreatment, flax and tomato showed symptoms of calcium deficiency.

The sulphur-deficient cultures did not produce typical symptoms, the general effect in old leaves being similar to that of low nitrogen but without the bright colorations and with growth remaining normal.

Observation of symptoms on the cereal cultures was seriously interfered with by attacks of Mildew.

No significant effects due to additional sodium chloride or sulphate were observed at the concentrations applied to plants growing in sand cultures.

THE DISTILLED WATER SERIES.

The distilled water series of sand cultures was designed to extend the technique of studying trace element deficiencies and to develop more refined methods which could still be applied on a moderately large scale, without undue expense, for the production of typical deficiency symptoms in a variety of crops. The experiments also included observations on the toxic effects of certain trace elements applied in excess.

Materials and Methods.

Pots and Sand.

The pots and sand were as described for the rainwater series. The pots were arranged in groups of three per treatment.

Nutrient Solutions.

The distilled water was obtained from copper stills and stored in glass carboys. All the nutrient solutions used supplied the essential elements in the same concentrations as in the rainwater series.

The following Analar chemicals were used for the boron deficient cultures : KNO_3, $CaCO_3$, HNO_3, Na_2HPO_4, H_2SO_4, $MgSO_4.7H_2O$, $FeCl_3.6H_2O$. The $Ca(NO_3)_2$ was prepared as required from the HNO_3 and $CaCO_3$, and the NaH_2PO_4 by dissolving Na_2HPO_4 in the theoretical quantity of dilute H_2SO_4, thereby raising the sodium and sulphate concentrations. The stock solutions for the boron deficient cultures were stored in waxed Winchesters previously washed out with concentrated HCl.

For purifying the nutrient solutions used in the manganese deficient cultures the adsorption technique of Steinberg (1) modified by Stout and Arnon (2) was employed. The ferric chloride used in the manganese deficient cultures was prepared as follows : to a concentrated boiling solution of ferric ammonium alum (Analar) was added about 5% of the total amount of dilute ammonia necessary to precipitate all the iron ; the liquid was cooled and filtered. The remainder of the ammonia solution was added, the precipitate was filtered and washed free of ammonia with hot distilled water. The precipitate was dissolved in distilled Analar HCl, and the precipitation repeated.

The trace elements were given separately once weekly as for the rainwater series with the addition of zinc at 0.1 p.p.m. No molybdenum was given.

In the experiments on toxicity, extra boron and manganese in concentrations expected to be toxic were given separately to 11-weeks-old tomato plants at 1.5 and 0.9 p.p.m. weekly respectively ; these amounts were increased to 2.5 and 1.5 p.p.m. (*i.e.* 5 times the normal dose) after a further 6 weeks. Excess zinc at successive levels from 0.5 to 120 p.p.m. was given to maize plants during growth over a period of 3 months.

Crops and Treatments.

The crops grown in the distilled water series and the treatments given are summarised in Table V.

TABLE V.

CROPS GROWN AND TREATMENTS GIVEN IN THE DISTILLED WATER SERIES.

Crop and Variety.		Omissions. In addition to complete nutrient culture.	Additions.
Wheat	Red Marvel	Fe, B, Mn	
Barley	Plumage Archer	Fe, B, Mn	
Oats	White Star	Mn	
Maize	Golden Bantam	Fe	Zn
Cauliflower	Majestic	Fe, B, Mn	
Sugar Beet		Fe	
Red Clover	Dorset Marlgrass	Fe	
Flax	Liral Prince	Fe, B, Mn	
Tomato	Market King	Fe, B, Mn	B, Mn
Potato	Majestic	Fe, B	

Sowing.

All seeds were sown in sand after the usual pretreatment and watered with the appropriate complete nutrient without trace elements. Tomatoes and brassicae were transplanted when about 3 in. and 4 in. high respectively.

Pests and Diseases.

No trouble was experienced except from Mildew on the wheat and barley and no control measures were employed after attempts, by removal of infected leaves, had been abandoned. The attack of Mildew on the wheat cultures made it impossible to record deficiency symptoms.

Systematic Description of Typical Symptoms.

Barley.

Omissions.

Iron. Young leaves with faint intervenal yellowing confused by effects of Mildew.

Maize.

Omitting *Iron.* Slight increase in natural striped variegation of younger leaves.

Excess *Zinc.* Slight reduction in vigour and size of cob but no characteristic symptoms.

Tomato.

Omissions.	Growth.	Leaves.	Roots.	Fruits.
Iron ..		Upper leaves slightly pale with faint intervenal mottling. Some marginal scorching and intervenal chlorosis and necrotic spotting of middle leaves was observed (T).		Considerable greenback (as in Mg def :)
Boron .. (15 weeks)	Slightly stunted stem tips occasionally bent sideways. Growing points sometimes deformed ; one observed defective and withered.	Some upper leaves with marginal chlorosis at base of leaflets followed by reddish and purple tints ; veins purple on underside scorching of tips and margins of leaflets. Petioles of leaflets brittle and frequently break down. At end of season symptoms similar to middle leaves of -Fe cultures above developed (T).	Greatly reduced, stunted, twisted, harsh, with considerable browning and gelatinisation at tips, most severe at top of rooting zone, *i.e.* in youngest roots.	
Manganese .. (10 weeks)	Almost normal, slightly spindly and	Mature leaves reduced, with intervenal mottling pale green at first, later yellow ; veins remaining very dark green. Pinpoint " peppery " necrotic spotting appearing in mottled areas, commencing near base of leaflets sometimes fusing into necrotic lesions along midrib. Larger necrotic areas may show successive irregular zones. Leaves shrivel ; symptoms eventually appear in tip leaves ; may not involve eldest leaves if these mature before deficiency becomes apparent.	Much reduced, shorter, finer, some tip browning.	Fruiting reduced but fruits apparently normal.
Additions.				
Boron .. (in toxic quantity : see note below)		Lower leaves with narrow very dark brown marginal scorching particularly at tips and serrations ; no chlorosis. Young leaves normal.		
Manganese ..		Very faint intervenal mottling of upper leaflets ; no characteristic symptoms.		

Note on boron toxicity. Plants tolerated 1.5 p.p.m. after 6 weeks ; symptoms then produced with 2.5 p.p.m.

Cauliflower.

Omissions.	Growth.	Leaves.	Stems.	Flowers.
Iron ..		Slight paling with fine patterned intervenal mottling (T).		
Boron .. (14 weeks)	Stunted. Slight tendency to sprouting between upper leaves.	Young leaves and petioles twisted; lower leaves paling at tips and margins followed by bright yellow and orange mottling (rim effect). Small necrotic intervenal areas near margins. (T) Petioles brown and upper surface roughened.	Roughened and cracked, surface curling back in in scaly patches and infected by mycelium. Pith with brown water-soaked areas.	Curd with indigo and brown areas on surface due to breakdown, water-soaked appearance inside.
Manganese ..		Fine grey intervenal mottling of old leaves with occasional necrotic areas and early defoliation (T).		

Sugar Beet.

Omitting *Iron.* Leaves in centre of crown pale green, with yellow-green fine-patterned intervenal mottling (T).

Flax.

Omissions.

Iron. Some apical leaves and stem tips pale green and finally yellow-green (T).

Boron. No outstanding symptoms observed; there was a tendency for the growing points to be deformed or aborted and slightly pale (T).

Manganese. No leaf symptoms observed: floral branches unusually stiff and brushlike (T).

Note.—The flax cultures from all series except the complete nutrient developed interesting but unexplained symptoms. Growth was temporarily arrested in some plants, the tip becoming rosetted with crowded leaves but later elongating normally. The lower, but not the basal, leaves developed white and pale brown scorched spots mainly at the leaf tips. These effects were provisionally ascribed to sun scorching.

Potato.

Omitting.	Growth.	Leaves.	Tubers.
Boron ..	Tendency to branching. Growing points weak.	Tip leaflets small, eventually becoming intervenally yellow green at margins and developing towards base of leaflet; margins blackening in places. Petioles brittle (T).	Varying in size from less than 2 in. to 5 in.; very small ones soft, brown; large ones with rough surface and often split at growing points end.

Notes on Cultures not producing Symptoms.

The presence of iron compounds in the sand was probably responsible for the general non-appearance of iron deficiency symptoms.

The plants grown in toxicity cultures containing extra Mg and Zn apparently were able to tolerate steadily increasing amounts. The same reaction took place, although more slowly, in tomatoes treated with excess boron.

The deficiency symptoms on wheat and barley were obscured by the effects of Mildew.

SUMMARY.

1. This progress report deals with work done during 1943 when 23 crops were grown in sand culture with controlled nutrient supply in continuation of work on the visual diagnosis of mineral deficiencies in plants.

2. The aims of the 1943 programme were (*a*) the extension and confirmation of existing records, (*b*) the examination of the effects of additional sodium sulphate and chloride with regard to the use of salt as a fertilizer, (*c*) the study of the problems of growing a wide range of crops on a large scale, (*d*) the development of an appropriate and economical trace element deficiency technique using rainwater and distilled water.

3. With the rainwater technique, using chemicals of re-crystallised or A.R. standard and unwashed sand, deficiencies of the following were observed : Nitrogen, potash, phosphorus, magnesium, in cauliflower, lettuce, radish, sugar beet, broad bean, red clover, flax, tomato, potato ; nitrogen, potash, phosphorus, in barley ; phosphorus in rape, cabbage, swede, turnip ; calcium, in flax, tomato, potato ; magnesium in maize, cabbage, turnip, dwarf bean ; boron in cauliflower, marrowstem kale, celery.

No significant effects were observed with additional sodium sulphate and chloride ; and only slight paling was noted in sulphur deficiency ; iron and manganese deficient cultures produced no leaf symptoms.

4. With the distilled water technique, using A.R. grade or highly purified chemicals and unwashed sand, deficiencies of the following were observed :— Iron in sugar beet, flax ; boron in cauliflower, tomato ; manganese in tomato.

Toxicity symptoms in tomatoes were observed with excess boron.

5. The use of unwashed sand is suitable for major element deficiency cultures and boron and manganese deficiencies, in some crops, but not for iron deficiency. The method of pretreatment with complete nutrient before sowing is suitable for deficiencies of nitrogen, phosphorus, potash, and magnesium in most plants. It is unsuitable for calcium deficiency, and for potassium and magnesium deficiencies in cereals.

Acknowledgments.

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The writer wishes to acknowledge the assistance of Mr. W. H. Neild and Miss M. Taylor in growing the experimental plants, and of Dr. R. L. Wain for the water analyses,

REFERENCES.

(1) Steinberg, R A. (1935). Nutrient solution purification for the removal of heavy metals in deficiency investigation with *Aspergillus niger*. *J. Agr. Res.* 51, 413.

(2) Stout, P. R. and Arnon, D. I. (1939). Experimental methods for the study of the role of manganese, copper, and zinc in the nutrition of high plants. *Amer. J. Bot.* 26, 144.

(3) Wallace, T. (1943). The diagnosis of mineral deficiencies in plants. A colour atlas and guide. H.M.S.O., London.

EXPERIMENTS ON THE CONTROL OF MAGNESIUM DEFICIENCY IN GREENHOUSE TOMATOES.

PROGRESS REPORT I.

By J. O. JONES, D. J. D. NICHOLAS and T. WALLACE.

During the latter part of the summer of 1942 several cases of severe magnesium deficiency in greenhouse tomatoes were brought to our notice. At one centre preliminary experiments were carried out to test the effectiveness of three different methods of treatment, viz. : (1) Injection of the plants with 1% solution of magnesium sulphate ; (2) Spraying the plants with 1% solution of magnesium sulphate ; (3) Application of magnesium sulphate at the rate of 4 cwt. per acre to the soil.

These trials were carried out in June when the plants were about 6 feet high and the trouble was very severe. None of the treatments gave any appreciable response presumably due to the advanced stage of growth and the severity of the deficiency.

Three centres where magnesium deficiency had been severe in 1942 were chosen for experiments in 1943.

CENTRE I.

This is the centre at which the 1942 treatments had been carried out.

The 1943 experiments were laid out in two houses: one house was steam sterilized and the other house treated with Steriform. The two houses afforded an opportunity of testing the effect of both methods of sterilization on the occurrence of magnesium deficiency.

Treatments.

House 2. This house was steam sterilized during the winter and received a dressing of straw compost at the rate of 24 tons per acre. The house was divided into four plots, receiving the following basal fertilizer treatment. The N.P.K. treatment comprised the grower's basal dressing.

Plot 1	N.P.K.Mg.
Plot 2	N.P.K.
Plot 3	N.P.K.Mg.
Plot 4	N.P.K.

The magnesium sulphate was applied at the rate of 6 cwt. per acre on 18/2/13, together with the grower's base dressing. About a week later the house was planted with the following varieties :—Vetomold, Mould Resister, Potentate and E.S.1. From 13/5/43 plots 1 and 3 received 2 cwt. per acre of magnesium sulphate as a top dressing at fortnightly intervals, making a total application including the basal dressing of 18 cwt. per acre.

House 3. This house was sterilized with Steriform during the winter and received a similar dressing of compost as house 2. The basal fertilizer treatment was also the same except that plots 1 and 2 received no potash. Plots 1 and 3 received top dressings of magnesium sulphate at about fortnightly intervals, making a total of 18 cwt. per acre.

On 13/5/43 the untreated plots 2 and 4 received a dressing of 6 cwt. per acre of magnesium sulphate. This house was planted throughout with E.S.1.

Results.

House 2. *Observational Data.* Severity of Magnesium Deficiency Symptoms.

Date.	Variety.	Plot 1.	Plot 2.	Plot 3.	Plot 4.
13/5/43	Vetomold	Trace	Very slight	—	—
	Mould Resister ..	—	Very slight	Trace	Trace
	Potentate	—	Severe	Medium	—
	E.S.1	—	Very slight	Trace	Trace
28/6/43	Vetomold	Trace	Very slight	—	—
	Mould Resister ..	—	Slight	Very slight	Slight
	Potentate	—	Slight	Very slight	—
	E.S.1	—	Trace	Trace	Trace

Chemical Data. Leaf samples for analysis were taken from Plot 2 on 13/5/43 and the results are presented in Table I.

Table I.

Variety.	Ash as % Dry Matter.	As % Ash.				As % Dry Matter.			
		CaO	MgO	K_2O	P_2O_5	CaO	MgO	K_2O	P_2O_5
Vetomold	30.90	33.62	1.01	25.91	3.54	9.76	0.32	7.07	1.10
E.S.1	30.13	32.63	1.00	23.57	2.73	9.30	0.32	6.92	0.88
Potentate ..	29.97	33.72	0.88	22.10	3.22	9.80	0.26	6.38	0.96

The deficiency symptoms did not develop to any considerable extent in this house.

Table I shows that, although the symptoms of magnesium deficiency were not very well developed, the actual content of magnesium in the plant was low.

House 3 *Observational Data.* Severity of Magnesium Deficiency Symptoms.

Date.	Plot 1.	Plot 2.	Plot 3.	Plot 4.
14/4/43	Slight	Medium	Medium	Severe
13/5/43	Slight-Medium	Medium-Severe	Medium	Medium-Severe
23/6/43	Slight-Medium	Severe	Medium	Severe
8/7/43	Medium	Severe	Medium	Severe

Chemical Data. Leaf samples for analysis were taken from this house at intervals. The data are presented in Table II.

Table II.

			As % Ash.				As % Dry Matter.			
Date.	Plots & Treatment.	Ash as % Dry Matter.	CaO	MgO	K_2O	P_2O_5	CaO	MgO	K_2O	P_2O_5
14/4/43	1. Mg	30.67	33.70	0.80	22.50	3.10	9.80	0.25	5.36	0.95
	2. Nil	28.97	33.43	0.64	22.35	3.23	9.62	0.18	5.13	0.93
	3. K.Mg	27.80	32.96	0.96	24.60	3.59	9.31	0.27	6.10	0.99
	4. K	27.46	33.52	0.87	24.83	3.53	9.71	0.20	6.22	0.97
13/5/43	1. Mg	26.43	33.23	0.79	21.90	2.20	9.72	0.26	5.60	0.72
	2. Nil	25.96	33.10	0.51	22.80	2.35	9.40	0.13	5.34	0.61
	3. K.Mg	28.55	33.26	0.76	25.40	2.30	9.33	0.22	6.88	0.66
	4. K	30.19	32.24	0.55	25.59	2.43	9.42	0.14	6.93	0.62
23/6/43	1. Mg.	24.48	32.37	1.10	23.70	2.68	9.10	0.37	5.83	0.70
	2. Nil	28.10	32.17	0.70	23.30	2.68	9.15	0.19	5.63	0.79
	3. K.Mg	30.60	33.65	1.01	26.30	2.55	10.30	0.31	7.43	0.78
	4. K	30.87	32.46	0.74	26.55	2.00	10.02	0.22	7.60	0.61

The observational data show clearly that the addition of magnesium sulphate either with or without potash reduces considerably the foliar symptoms of magnesium deficiency, and that where potash was added the symptoms were much more severe. It is evident from Table II that there is an increase of both potassium and magnesium in the leaves from the treated plots.

Table III shows the seasonal increase of magnesium in the treated plots as compared with the controls both with and without potash.

TABLE III.

Date.	Difference in % MgO between Plots 1 & 2.	Difference in % MgO between Plots 3 & 4.
14/4/33 ..	.07	.07
13/5/43 ..	.13	.08
23/6/43 ..	.18	.09

The above table suggests that the intake of magnesium has been greater in the absence of the potash dressing.

CENTRE II.

In 1942 magnesium deficiency symptoms were very severe at this centre and the worst house was chosen for trial in 1943.

Treatments.

Not Sterilized.	Sterilized with Formaldehyde.
Plot 1. Mg.	Plot 5. K.Mg.
Plot 2. Nil.	Plot 6. K.
Plot 3. K.Mg.	Plot 7. K.Mg.
Plot 4. K.	Plot 8. K.

Plots 1—4 were not sterilized whilst plots 5—8 were sterilized with formaldehyde. Plots 1 and 3 were given an initial dressing of 8 cwt. per acre of magnesium sulphate with two additional top dressings, making a total of 12 cwt. per acre. Plots 5 and 7 received an initial dressing of 4 cwt. per acre with two additional top dressings, making a total of 8 cwt. per acre. Where potash was given it was applied in the grower's basal dressing. The dressings were applied on 15/3/43 and the house planted a few days later.

Results.

Observational Data. Severity of Magnesium Deficiency Symptoms.

Date.	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.	Plot 7.	Plot 8.
14/5/43 ..	Nil	Trace	Trace	Trace	Trace	Trace	Trace	Trace
10/6/43 ..	Trace	Severe	Slight	Severe	Slight	Severe	Medium	Severe
30/6/43 ..	Slight	Severe	Slight	Severe	Slight-Medium	Severe	Slight-Medium	Severe

Chemical Data. Leaf samples for analysis were taken on 30/6/43. The results are given in Table IV.

TABLE IV.

Plots and Treatment.	Ash as % Dry Matter.	As % Ash.				As % Dry Matter.			
		CaO	MgO	K_2O	P_2O_5	CaO	MgO	K_2O	P_2O_5
1. Mg. ..	26.78	35.89	1.50	20.20	3.08	9.60	0.40	4.46	0.82
2. Nil ..	24.36	34.60	0.90	21.13	3.08	8.43	0.22	5.16	0.75
3. K.Mg. ..	26.87	34.84	1.21	24.06	3.11	9.36	0.33	6.41	0.84
4. K. ..	24.56	34.64	0.92	24.65	3.87	8.51	0.23	6.20	0.95
5. K.Mg. ..	27.85	35.37	1.40	26.80	3.04	8.92	0.39	6.72	0.85
6. K. ..	25.06	36.80	1.08	26.54	3.20	9.23	0.27	6.60	0.80
7. K.Mg. ..	29.75	35.92	1.12	23.60	2.83	9.80	0.34	7.20	0.84
8. K. ..	25.46	38.34	0.75	26.52	2.70	9.76	0.20	6.91	0.71

The observational data at this centre again show that the addition of magnesium sulphate has substantially reduced the severity of the foliar symptoms both with and without the addition of potassium. Where potassium was omitted magnesium deficiency symptoms tended to be less severe.

The chemical data again show a higher potassium and magnesium content where these constituents were added. The depressing effect of potassium on the intake of magnesium is also apparent.

CENTRE III.

At this centre severe magnesium deficiency symptoms were observed in 1942, and a house showing the most severe symptoms was chosen for trial in 1943.

Treatments.

The house was steam sterilized at the end of March, and on 15/4/43 was divided into 4 plots which received the same treatments as plots 1—4 in Centre II.

Planting was done a few days after the application of the fertilizers.

Results.

Observational Data. Severity of Magnesium Deficiency Symptoms.

Date.	Plot 1.	Plot 2.	Plot 3.	Plot 4.
28/8/43	Trace	Very slight	Very slight	Slight
4/9/43	Very slight	Slight	Slight	Medium.

Magnesium deficiency symptoms did not develop to such a marked degree as in 1942, suggesting, as in Centre I, that steam sterilization may give a partial control.

Summary.

1. Experiments on the control of magnesium deficiency in greenhouse tomatoes were carried out at one centre in 1942 and at three centres in 1943.

2. The 1942 treatments which were given in June were as follows :— Injection of plants with 1% solution of magnesium sulphate ; application of magnesium sulphate at 4 cwt. per acre to the soil ; spraying with 1% solution of magnesium sulphate.

3. The treatments applied in 1943 consisted of the application of magnesium sulphate to the soil at rates from 4—8 cwt. per acre before planting, and top dressings at 2 cwt. per acre in the presence and absence of potash in the basal dressings.

4. The 1942 treatments were unsuccessful, while the 1943 treatments gave a marked degree of control.

5. A more satisfactory result was obtained where magnesium sulphate was used in the absence of potassium.

6. Deficiency symptoms were less severe where steam sterilization treatment was given.

7. The results suggest that considerable control of magnesium deficiency in greenhouse tomatoes can be obtained by the addition of 4—8 cwt. per acre of magnesium sulphate (calcined Kieserite 30% MgO) to the basal fertilizer dressing.

MANURIAL EXPERIMENTS ON VEGETABLE CROPS.

V.—EFFECTS OF FARMYARD MANURE AND OF VARIOUS FERTILISER TREATMENTS ON SPRING CABBAGE AND CAULIFLOWER.

By H. E. CROXALL and P. T. H. PICKFORD.

The results presented in this paper are for spring cabbage and cauliflower, the fourth and fifth crops of the series in which the previous crops were savoys, carrots (1) and onions (2). The layout of the plots and the scheme of manurial treatments has been described in a previous paper (1). For both spring cabbage and cauliflower the farmyard manure dressing was maintained at 10 tons per acre, the rate applied to the previous onion crop. The nitrogen dressing for the other plots was 8 cwts. per acre of nitro-chalk, 4 cwts. per acre being applied as a base dressing and the remainder as a top dressing.

I. SPRING CABBAGE.

The spring cabbage, variety Durham Early, was planted on October 18th by a robot planter. The plants were severely attacked by cutworms and many gaps had to be filled in during the end of the month. Owing to soil wetness mortality was high in all plots. The top dressing was applied on March 4th and observations on the growth of the plants were made on April 21st. Table I indicates the relative growth for the different treatments. The maximum number of points possible is twelve.

TABLE I.

Complete Fertilizer (N.P.K. with Sulphate of Potash).	Potash Omitted.	Nitrogen Only.	Phosphate Omitted.	Farm Yard Manure.	Nitrogen Omitted.	Nitrogen, Phosphate, Muriate of Potash.	Nitrogen, Phosphate and Salt.
7½	7½	7	6	5½	3	7¾	7¼

Growth was not good in any plot. The nitrogen omitted plots were distinctly worse than any others, the plants being pale and failing to heart. The plants in the farmyard manure plots were also rather pale.

The crop was cut on May 12th, but owing to the poor stand no weights were recorded. No definite conclusion can be drawn from this crop, but the very poor growth in the nitrogen omitted plots is worth noting.

II. CAULIFLOWER.

Cauliflowers, variety November (Clucas) were planted on the plots on June 1st. The rows were 2ft. apart and the plants 2ft. apart in the rows. All plots except those receiving farmyard manure and no nitrogen were top dressed on August 4th.

Results.

Observations on the growth of the plots were made on September 7th, the results of this growth marking being given in Table II.

TABLE II.

Complete Fertilizer (N.P.K. with Sulphate of Potash.)	Potash Omitted.	Nitrogen Only.	Farm Yard Manure.	Phosphate Omitted.	Nitrogen Omitted.	Nitrogen, Phosphate and Muriate of Potash.	Nitrogen, Phosphate and Salt.
10½	9½	9¼	9	8¼	6½	11¼	11½

The growth in the plots from which nitrogen was omitted was outstandingly poor. The plants were pale green in colour with the outer leaves turning purple and dying. In all the other plots growth was good, especially in those receiving muriate of potash and salt. The plants receiving farmyard manure were slightly pale, indicating some shortage of nitrogen. There were no symptoms of potash or phosphate deficiency showing on any plants at this date, but at the time of cutting the plants in the potash omitted plots showed the marginal scorch typical of potash deficiency.

The cauliflowers were cut between September 28th and November 24th and the total yields per plot recorded. The yields, excluding those from the muriate of potash and salt plots which are separate from the main experiment were analysed statistically and are given in Table III.

TABLE III.

Crop Weights of Cauliflower (Tons per acre).

Potash Omitted.	Complete Fertilizer with K_2SO_4	Nitrogen Only.	F.Y.M.	Phosphate Omitted.	Nitrogen Omitted.	Nitrogen, Phosphate, Muriate of Potash.	Nitrogen, Phosphate, Salt.
10.3	9.6	8.5	8.3	7.2	3.9	13.9	13.9

S.E. 0.83 tons.
Difference required for significance at 5% pt. 2.63 tons.
„ „ „ 1% pt. 3.74 „

The yields from the nitrogen omitted plots are significantly lower than those from all other plots. The difference is significant at the 1% pt. level in all cases except the phosphate omitted treatment. The difference between

the yields of the potash omitted and the phosphate omitted plots is significant at the 5% pt., and the difference between the complete fertilizer and the phosphate omitted plot is almost significant.

Although not included in the analysis, the yields from the muriate of potash and salt plots were high and suggest that chloride-containing fertilizers have no harmful effect on cauliflowers.

These results indicate the predominant importance of nitrogen for the growth of cauliflowers. Potash was entirely ineffective in increasing yield, although the omission of it did cause symptoms of potash deficiency to appear late in the season. There is some indication that the omission of phosphate may reduce yield. The results are very similar to those obtained with savoys on the same plot (1). Excluding the salt, muriate and farmyard manure plots the yields are in the same order on the two experiments. The comparative increase in yields of the farmyard manure plots in the current experiment is probably due to the fact that the dressing was applied at twice the rate employed in the savoy experiment.

Summary.

1. A description is given of manurial experiments on spring cabbage and cauliflower, these crops continuing the rotation reported in Parts I and III of this series.

2. Owing to cutworm and wet soil conditions no crop weights were obtained for the spring cabbage crop. The only observation of any importance was the extremely poor growth of the nitrogen omitted plots.

3. The results on cauliflower indicated the predominant need of this crop for nitrogen. Omission of phosphates probably decreased yield, but omission of potash did not. Muriate of potash and salt produced no injury and plots receiving either of these gave very high yields.

Acknowledgment.

These experiments were originated by the Director, Professor Wallace, whose advice is gratefully acknowledged.

REFERENCES.

(1) Wallace, T., Croxall, H. E. and Pickford, P. T. H. Manurial Experiments on Vegetable Crops. I. Effects of Farmyard Manure and of various Fertiliser Treatments on Savoys and Carrots. *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton*, p. 25, 1941.

(2) Wallace, T., Croxall, H. E. and Pickford, P. T. H. Manurial Experiments on Vegetable Crops. III. Effects of Farmyard Manure and of various Fertiliser Treatments on Onions. *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton*, pp. 32-33, 1942.

MANURIAL EXPERIMENTS ON VEGETABLE CROPS.

VI.—EFFECTS OF FARMYARD MANURE AND OTHER MANURIAL TREATMENTS ON YIELD AND STORAGE ROTS OF ONIONS.

By H. E. CROXALL and P. T. H. PICKFORD.

The onion crop discussed in this paper was the fifth crop in the series in which the previous crops were savoy, early potatoes (1), spring cabbage and carrots (2). The manurial treatments and the arrangement of the experiment are described in a previous paper (1). The fertilisers used and the rates of application were the same as for the preceding carrot crop (2). The nitro chalk rate was again 3 cwts. per acre, while the hoof and " sludged " town refuse plots were applied at a rate to supply twice the nitrogen in the nitro chalk dressing. The onions, variety Bedfordshire Champion, were drilled in rows one foot apart on 8th March. The drilling rate was approximately 3½ lbs. of seed per acre. Germination was satisfactory.

Results.

The plots were very even throughout the season, so that no attempt was made to record growth markings.

The crop was lifted on August 9th and dried on ground cleared from weeds. The crop was sorted into pickling and ware onions and bagged from September 14th—18th. The total yields and yields of ware onions were recorded and analysed statistically. The results are given in Table I.

TABLE I.

YIELDS OF ONIONS (Tons per Acre).

	Farmyard Manure (5 tons) + Inorganic Nitrogen.	Complete Fertiliser with Hoof.	Compost + Inorganic Nitrogen.	Complete Inorganic with Potash Salts.	Complete Inorganic with Sulphate of Potash.	Farm-yard Manure (10 tons).	Sludge/ Town Refuse Compost.	Complete Inorganic + Magnesium Sulphate.	S.E.	Difference required for significance at 5% pt.
Total Yields of Onions ...	14.8	14.4	14.2	13.9	13.5	13.4	12.8	12.4	0.69	2.1
Yields of Ware Onions	12.0	11.4	11.7	11.5	10.9	9.5	9.9	9.4	0.62	1.9

The total yields of onions provide little information. The difference between the highest yield, from the farmyard manure plus inorganic nitrogen plots, is significantly greater at the 5% pt. than the lowest yield from the complete fertiliser plus magnesium sulphate. This is of no importance, as the difference in yields from the plots receiving complete inorganic fertiliser and the plots with the same treatment plus magnesium sulphate is not significant.

The farmyard manure plus inorganic nitrogen treatment produced the highest yield of ware onions. A high yield was also given by the compost supplemented by nitro-chalk and by the complete fertiliser containing hoof. On the other hand the plots receiving only organic material, that is the farmyard manure and sludge plots, gave low yields. The yield was high from the plots receiving the complete inorganic fertiliser including potash salts, but not significantly higher than the yield from the plots in which the potash was supplied as sulphate. A low yield was given by the complete fertiliser plus magnesium sulphate, but it was not significantly lower than the yield from the complete inorganic treatment.

Storage Experiment.

A random sample of 40 lbs. of apparently sound ware onions was taken from each plot and placed in trays on October 1st. The trays were arranged in blocks in a shed with one side open to allow good ventilation. The onions were examined at four-weekly intervals and any showing signs of decay were removed. The total weights removed up to each date were calculated for each sample and the results analysed statistically. These results are summarised in Table II. In graph I the percentage loss by weight through rotting is plotted against time.

After four weeks the weight of rotted onions from the farmyard manure plus inorganic nitrogen treatment was significantly greater at the 1% pt. than that from all other treatments. The complete inorganic plus magnesium sulphate treatment also gave a high amount of rot which was significantly greater than that in the farmyard manure alone, hoof, and sludge treatments at the 5% pt. and the complete fertiliser with potash salts at the 1% pt. The amount of discarded onions in this latter treatment was significantly lower than that from all other treatments except the hoof and farmyard manure treatments.

After eight weeks both the farmyard manure plus inorganic N and complete inorganic fertiliser plus magnesium sulphate, had significantly more rotten onions than all other treatments except the compost plus inorganic nitrogen treatment. The weight of rots from the potash salts treatment was significantly lower than from all treatments except the farmyard manure, hoof, and complete fertiliser with sulphate of potash treatments, and the difference was almost significant for the two last-mentioned treatments.

The rate of loss in the complete fertiliser with potash salts increased and the weight of rotten onions was not significantly lower than that in any other treatments on the last three inspections. The rate of rot in the farmyard manure plus inorganic nitrogen and the complete fertiliser plus magnesium sulphate treatments fluctuated somewhat but remained high until the end of the experiment. The rate of loss in the farmyard manure treatment fell in comparison with the other treatments, but the final weight of discarded onions was only significantly lower than that from the farmyard manure plus nitrogen and complete fertiliser plus magnesium sulphate treatments.

Thus there appeared to be a definite tendency for onions which received the farmyard manure plus inorganic nitrogen and the complete fertiliser plus magnesium sulphate to rot more readily than those which received any other manurial treatment. Onions from the plots receiving the complete fertiliser with potash salts seemed less susceptible to rots in the early storage period.

TABLE II.

MEAN WEIGHTS OF ROTTED ONIONS IN LBS.

Time in Weeks from Oct. 1st	Farmyard Manure (5 tons) + Inorganic Nitrogen	Complete Fertlliser with Hoof	Compost + Inorganic Nitrogen	Complete Inorganic with Potash Salts	Complete Inorganic with Sulphate of Potash	Farmyard Manure (10 tons)	Sludge/ Town Refuse Compost	Complete Inorganic + Magnesium Sulphate	S.E.	Difference required for significance.	
										5% pt.	1% pt.
4	11.6	6.1	7.7	5.3	7.5	6.8	7.7	8.9	0.56	1.71	2.38
8	19.9	15.2	17.0	12.4	15.2	14.3	15.8	18.7	1.47	3.14	4.35
12	22.9	20.0	20.9	18.5	19.8	18.9	19.9	22.2	0.95	2.87	4.00
16	25.9	23.8	23.4	22.6	22.3	21.5	23.0	25.0	1.06	3.21	4.46
20	30.7	27.8	27.8	27.6	27.2	26.2	27.9	30.4	0.92	2.78	3.86

It was not possible to determine the cause of rots, especially in the early stages, by a superficial observation, although in some cases the presence of typical conidia and sclerotia suggested the causal agent was *Botrytis allii*. Bulbs were therefore selected at random and isolations made from them. The bulbs were surface sterilised and tissue from the diseased area inside the bulb, usually just below the neck, was plated out on malt agar. The fungus most frequently isolated was *B. allii*, which was obtained in 72% of the cultures. In 26% a fungus was isolated which agreed with the description of *B. byssoidea* given by Walker (3). Some of the onions from which this fungus was isolated were kept until a later stage in the rot developed and the symptoms were as described by that author. In the remaining 2% of the cultures species of *Penicillium* only were obtained. *Penicillium* spp. were also present on the surface of bulbs from which *Botrytis* was isolated.

Summary.

1. The results are given for the effect of various fertiliser treatments on the yields and keeping qualities of onions, continuing the crop rotation described in Parts II and III of this series.

2. There were no significant differences in the total yields of onions with any treatment.

3. The highest weights of ware onions were given by the treatments in which inorganic nitrogen was used to supplement farmyard manure and compost. A high yield was also given by the complete fertiliser containing hoof. Smaller yields were given by farmyard manure, sludge/town refuse compost, and complete fertiliser plus magnesium sulphate treatments.

4. In the storage experiment the highest percentage of rotten onions was found in the farmyard manure plus nitrogen and the complete fertiliser plus magnesium sulphate treatments. Farmyard manure alone gave the lowest final percentage of rots.

5. The fungus most frequently isolated from rotting bulbs was *Botrytis allii*, though *B. byssoidea* was present in 26% of the isolations made and Penicillium species in 2%.

Acknowledgment.

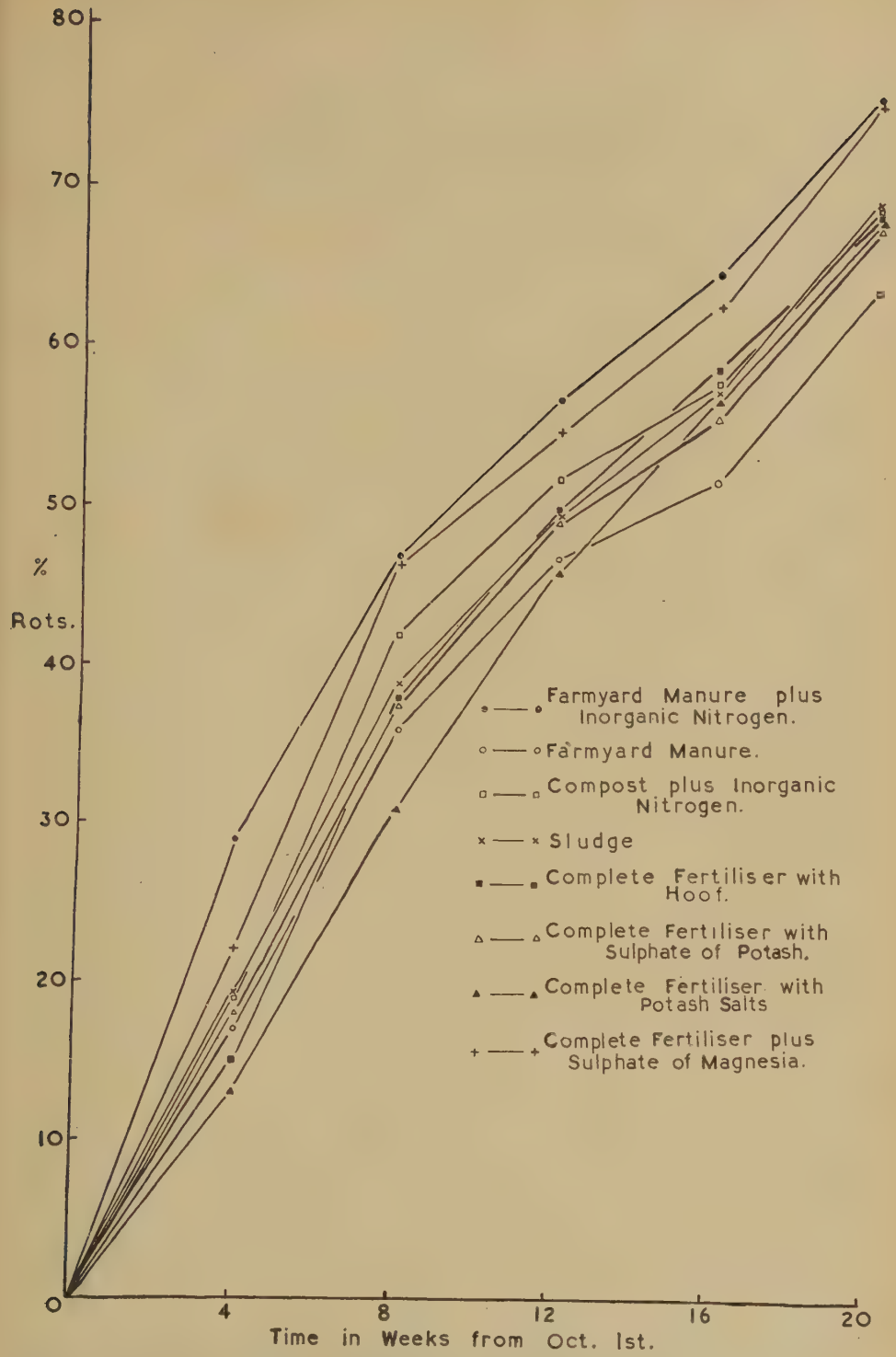
The authors' thanks are due to the Director of the Research Station, Professor Wallace, who originated this series of experiments, for the advice given in the course of the present year's work.

REFERENCES.

(1) Wallace, T., Croxall, H. E. and Pickford, P. T. H. Manurial Experiments on Vegetable Crops II. Effects of Farmyard Manure and other Manurial Treatments on Savoys and Early Potatoes. *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton*, p. 33, 1941.

(2) Wallace, T., Croxall, H. E. and Pickford, P. T. H. Manurial Experiments on Vegetable Crops IV. Effects of Farmyard Manure and other Manurial Treatments on Spring Cabbage and Carrot Crops. *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton*, pp. 34—37, 1942.

(3) Walker, J. C. Botrytis neck rots of onions. *J. Agric. Res.*, XXXIII, 893—928, 1926.



GRAPH I. EFFECT OF MANURIAL TREATMENTS ON INCIDENCE OF STORAGE ROTS IN ONIONS.

THE QUALITATIVE EXAMINATION OF INSECTICIDAL PROPERTIES.

PROGRESS REPORT—1943.

By H. MARTIN, A. STRINGER and R. L. WAIN.

The conventional classification of insecticides into those which are ingested by the insect (stomach poisons), those which act by contact with the integument (contact insecticides, including ovicides) and those which act through the respiratory system (fumigants) is of great practical utility, though in many cases more than one type of action is responsible for the toxicity of the insecticide and the precise subdivision into which the insecticide should be placed is difficult to assess.

Nicotine, for example, is usually regarded as a typical contact insecticide yet McIndoo (1916), as a result of the first extensive investigation of the mode of action of nicotine, concluded that it entered the insect system as a vapour and should therefore be classed with the fumigants. This conclusion was questioned by Richardson and Shepherd (1930) because the ready solubility of nicotine in water would suggest that it will enter the insect system as ions or molecules in solution. The particular insects used in the later investigation were the larvae of the mosquito *Culex pipiens*, and Richardson and Shepherd, concluding that the site of absorption is the wall of the alimentary tract, imply that nicotine here acts as a stomach poison.

Another example is sodium fluoride, long used to kill cockroaches, which Shafer (1915) suggested, cleaned their feet from the irritating powder by drawing them through their mouth parts thus ingesting the fluoride. Yet Sweetman (1941) found that roaches dusted with sodium fluoride were killed within 24 hours even when their mouth parts were sealed to prevent a direct stomach poison action. Griffiths and Tauber (1943) showed that though sodium fluoride can act as a stomach poison, its contact effect is primarily and mainly responsible for insecticidal action.

These examples suffice to show the difficulties met in insecticidal classification, yet in the case of the insecticide applied to foliage for the control of mandibulate insects another complication appears. For here, in addition to the possibilities of fumigant action, of a direct stomach poison action, and of death through contact with the insecticidal deposit, there is the possibility that the insect will refuse to eat the insecticide-treated foliage which thus escapes attack by the deterrent action of the insecticide. It is evident that such insectifugal properties must be investigated alongside true toxicity in the examination of potential or known insecticides.

The immediate object of the work to be described in this series of reports has been to devise rapid routine methods for the laboratory examination of these four types of insecticidal action, not only in established insecticides but in the synthetic chemicals daily added to the list of those for which insecticidal properties are claimed. As the purpose of these tests has been to sort out

compounds for field trial as substitutes for imported insecticides, no special attempts were made at quantitative comparison, though techniques ultimately capable of rigid standardisation were selected where possible, for it is intended that, from this preliminary work of survey, laboratory methods will be evolved suitable for the analytical study of the field performance of insecticides on the lines already developed for the evaluation of protective fungicides (Martin, 1943).

Methods.

(a) Stomach Poisons and Repellents.

To differentiate stomach poison and contact effects it is necessary to introduce the insecticide directly by mouth, avoiding contact between the insect exterior and the insecticide. The ability of certain leaf-eating larvae to imbibe drops of water placed in their path has been used by previous investigators (e.g. see Campbell, 1926), but this method is applicable only to water-soluble insecticides, a serious limitation, for a stomach poison to be effective in practical use must be virtually water-insoluble. Attention was therefore turned to modifications of the leaf-sandwich method, originally devised by Campbell and Filmer (1929) for the testing of insecticidal dusts. Briefly, a known amount of the insecticide is placed on a disc cut from the leaf and is covered by a second disc of similar diameter. The chance of accidental contact of insect and deposit is thus eliminated, and from the area of sandwich eaten the dose of insecticide consumed can be calculated. Moreover, since the amount of leaf eaten can be determined, deterrent action can be assessed by comparison with the amount eaten of sandwiches untreated with insecticide.

This method would be suitable only for voracious feeders which would take simultaneously the two discs of a sandwich, for, if one disc only is eaten, the insecticidal layer would become exposed, restoring the possibility of a contact action. Nor would it be suitable for use with shy feeders unwilling to take food material presented to them in a manner unlike that to which they are accustomed. It is for these reasons unlikely that the method will enable the assessment of deterrent action to the more fastidious kinds of insect pest against which the use of deterrents is more likely to be successful in practice.

Method.

Discs of 18 mm. diameter were cut by means of a cork borer from the young unwrinkled leaves of cabbage plants grown in seed boxes in the glasshouse. To the upper surface of one disc was added one drop (0.02 ml.) of an acetone solution of known concentration of the insecticide under test. The upper surface of a second disc was smeared with lanolin, this disc inverted and pressed by means of a rubber bung to the first disc on which, after the evaporation of the acetone, an evenly distributed deposit of insecticide was visible. The sandwiches were kept on moist filter paper in petri dishes until required as food.

The test insects used were miscellaneous species of cabbage-infesting larvae, most being the Cabbage Moth (*Mamestra brassicae* L.). The caterpillars, hand-collected from brussel sprout plants, were held in shallow basins

(half Petri dishes) of about 10 cm. diameter and covered by butter muslin stitched across a 12 cm. metal ring. To prevent the escape of large *M. brassicae* larvae it was necessary to cover the muslin with a circle of perforated zinc. No attempt was made to use the same instar in comparative tests except in the case of *M. brassicae* which was grouped as large larvae (instars already having a brown coloration) and small larvae (of a greenish yellow colour). In comparative tests, however, the samples chosen for each test were of approximately equal weight to avoid a preponderance of smaller or heavier larvae in any one treatment.

Each batch was fed with the appropriate sandwiches and examined at intervals to ensure an adequate food supply. Observations were continued if necessary until pupation, and those larvae developing signs of parasitism (observed only in *Pieris brassicae* L. and *P. rapae* L.) were ignored. Cannibalism was common in *M. brassicae*, the larger larvae attacking dead or moribund larvae.

(b) Contact Insecticides.

Methods for the evaluation of contact insecticides, reviewed by Tattersfield (1939) have now reached an advanced stage and provide results which, subjected to the appropriate statistical technique (see e.g. Morrison, 1943), enable fine differences to be detected. Indeed the possibility of employing biological methods in place of the less accurate chemical methods for insecticides based on pyrethrum has been explored at Rothamsted (Tattersfield and Potter, 1943) and at Slough (Parkin and Green, 1943). There is accordingly no call for exploratory work in this subject, but need was felt for a simple rapid qualitative method for the detection of contact insecticidal properties in previously untried compounds.

For rapid work application in dust form was chosen in place of spraying, the chemical to be tested being deposited from acetone solution on a carrier consisting of ground gypsum (95% by wt.) and amorphous silica (5% by wt.) previously mixed in a ball mill. Resistant test organisms such as earwigs (*Forficula* spp.) and woodlice were gently rotated in a beaker with a small amount of the dust and transferred to a Petri dish lined with a 9 cm. filter paper, excess of dust being removed from the filter paper by suction through a fine glass tube attached to a filter pump. Small pieces of cut potato tuber were added to the dishes containing woodlice to provide moisture; pieces of cabbage leaf were placed in those containing earwigs to reduce their tendency to shelter below the filter paper.

In the case of less resistant test insects such as larvae collected from brussel sprout plants, the dust was applied from a small pump-actuated duster held at a fixed distance above the edge of a sheet of foolscap on which the larvae were placed. If touched the larvae remained stationary in a curled position long enough for the application of a fixed number of puffs of dust. Usually four puffs were applied giving a deposit of about 6 mg. per 100 sq. cm. of surface. The larvae were then transferred to Petri dishes covered by muslin and by perforated zinc if necessary. Fresh torn cabbage leaf was added and the effect of the treatment observed over a period.

Results.

A. Rotenone and Allied Insecticides.

In addition to crystalline rotenone, a derris resin containing 25% rotenone and a ground Lonchocarpus root containing 5% rotenone were used. The latter was ground in a ball mill with one-half its weight of amorphous silica yielding the dust referred to as 67%, and this was diluted with the gypsum-silica carrier to give the 25% and 5% dusts.

The results obtained with the extract and rotenone as stomach poisons are assembled in Table I, the number of larvae unaffected out of those used per test being expressed fractionally, e.g. in Test E 3a, all seven (7/7) larvae were unaffected when examined 140 hours after being given discs prepared from 5% rotenone in acetone; the average amount consumed per larvae was 0.5 disc, ≡ 0.5 mg. rotenone. When used as a contact insecticide, rotenone and Lonchocarpus root gave the results of Table II.

TABLE I.

DERRIS EXTRACT AND ROTENONE AS STOMACH POISONS:

1 disc — 0.02 ml. acetone solution of insecticide.

Insect and Test No.	Time hr.	Rotenone. 10%	Rotenone. 5%	Rotenone. 0.5%	Derris resins. 33.3%	Derris resins. 3.33%	Acetone.
M. brassicae:							
E 3a	140	—	7/7 normal (0.5 disc)	8/8 normal (0.7 disc)	—	—	5/5 normal (1.0 disc)
E 3b	140	—	7/7 normal (0.5 disc)	7/7 normal (0.9 disc)	—	—	
E 5a	48	—	6/6 normal (0.5 disc)	—	4/5 normal (0.5 disc)	5/5 normal (1.0 disc)	5/5 normal (1.2 disc)
E 5b	48	—	2/2 normal	—	1/1 normal	1/1 normal	1/1 normal
E 8a	48	—	6/7 normal (0.3 disc)	5/5 normal (0.6 disc)	—	—	6/6 normal (0.8 disc)
E 8b	48	—	3/3 normal (0.7 disc)	—	—	—	3/3 normal (1.3 disc)
E 12	48	—	4/4 normal (0.4 disc)	—	—	—	4/4 normal (0.8 disc)
E 15	72	0/6 normal (1.3 disc)	—	—	—	—	5/6 normal (1.8 disc)
Pionea:							
E 5	48	—	1/1 normal	—	1/1 normal	1/1 normal	1/1 normal
P. rapae:							
E 5	48	—	1/3 normal	—	0/3 normal	1/2 normal	1/3 normal
E 8	48	—	0/6 normal (negligible)	—	—	—	—
P. brassicae:							
E 12	48	—	0/4 normal (negligible)	—	—	—	4/4 normal (0.5 disc)
E 15	72	0/8 normal (negligible)	—	—	—	—	5/5 normal (0.8 disc)

TABLE II.

ROTENONE AND LONCHOCARPUS ROOT AS CONTACT INSECTICIDES.

Test Organism and No.	Time hr.	Lonchocarpus Root.			Rotenone.		Carrier alone.
		67%	25%	5%	1%	0.5%	
M brassicae :							
E 4	116	—	—	—	—	6/7 normal	5/5 normal
E 6a	56	—	6/6 normal	—	5/5 normal	—	5/5 normal
E 6b	56	—	5/5 normal	—	7/7 normal	—	6/6 normal
E 7	72	9/12 normal	—	—	—	—	4/4 normal
E 9a	72	—	6/6 normal	—	—	—	6/6 normal
E 9b	72	—	4/4 normal	—	—	—	6/6 normal
P. rapae :							
E 9	72	—	—	4/4 normal	—	—	3/3 normal
E 13	72	—	3/4 normal	—	—	—	2/2 normal
P. brassicae :							
E 9a	72	—	—	9/10 normal	—	—	10/10 normal
E 9b	72	—	—	8/10 normal	—	—	
E 13	72	—	4/8 normal	—	—	—	6/6 normal
Forficula spp.							
B 1	25	4/15 normal	—	—	—	—	7/12 normal
B 3	48	2/10 normal	—	—	—	—	6/8 normal
B 4	48	9/13 normal	—	—	—	—	5/10 normal
Woodlice :							
C 1	48	10/11 normal	—	—	—	—	25/27 normal
C 2	48	10/13 normal	—	—	—	—	13/14 normal

Discussion.

The contact insecticidal properties of rotenone and of Lonchocarpus root against the insects tested are slight, many surviving treatment in the high concentration of 67% root.

As a stomach poison, rotenone exhibits a marked specificity of action, being toxic to the *Pieris* larvae at concentrations far below those tolerated by *Mamestra* larvae. The results confirm those of Swingle (1934), who found that the larvae of *P. rapae* died after eating leaf sandwiches of gelatine films containing derris, but survived contact with derris. On the other hand the conclusion of Speyer, Read and Orchard (1939) that larvae of *P. rapae* are killed by contact with Lonchocarpus powder is not supported. The latter workers reported, however, that few *Mamestra* larvae died as a result of contact action, and they concluded that the control of these pests given by Lonchocarpus was effected by deterrent action. In the present results consistently less of the rotenone-treated food was taken than in the control-with-lanolin-treated food which, in the absence of toxic symptoms, is evidence of the deterrent action of rotenone.

B. · Polychlorethane derivatives.

In 1942 information was received by letter from Dr. R. Maag, of Zurich, of highly-successful trials with a new synthetic insecticide discovered by the Swiss firm of J. R. Geigy A.G., and marketed in Switzerland under the name Gesarol. The corresponding trade name Guesarol has been registered in this country. This discovery is protected by B.P. 547871 and B.P. 547874, which describe the active constituents to be compounds of the series $R_1R_2CHCX_3$, wherein X = chlorine or bromine, R_1R_2 are organic radicals containing at least 3 and 5 carbon atoms respectively. In the examples cited in the patents, X is chlorine, $R_1 = R_2$ = phenyl, tolyl, chlorophenyl, bromophenyl, nitrophenyl, *o*- and *p*-dichlorphenyl respectively.

Certain of these and analogous polychlorethanes were therefore prepared by the condensation of the appropriate aromatic derivative with anhydrous chloral in the presence of sulphuric acid.

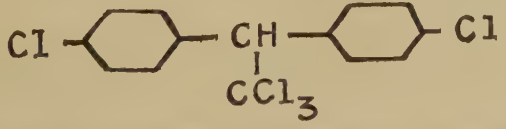
αα-diphenyl ββ-trichlorethane $(C_6H_5)_2CH.CCl_3$: from benzene and chloral ; crystallising from ethyl alcohol in thin leaflets, m.p. 60-62°C. ; Baeyer (*Ber.*, *5*, 1098) gives m.p. 64°C.

αα-bis(hydroxyphenyl) ββ-trichlorethane $(C_6H_4OH)_2CH.CCl_3$: from phenol and chloral ; re-crystallised from glacial acetic acid, m.p. 202°C (d). Ter Meer (*Ber.*, *7*, 1201) gives m.p. 202°C (d).

The correspondingly diacetate $(C_6H_4.O.COCH_3)_2CH.CCl_3$ was prepared by heating the above with excess of acetic anhydride and sodium acetate. It crystallised from ethyl alcohol in white needles of m.p. 140°C. Ter Meer gives m.p. 138°C.

αα-bis(x-chlorphenyl) ββ-trichlorethane $(C_6H_4Cl)_2.CH.CCl_3$: from chlorbenzene and chloral. Re-crystallised from methyl alcohol in white needles of m.p. 107°C. Zeidler (*Ber.*, *7*, 1180) gives m.p. 105°C.

The orientation of the chlorphenyl groups in this compound was established by its oxidation with chromic acid followed by steam distillation which gave a derivative crystallising from ethyl alcohol in white leaflets, m.p. 143-144°C. This substance, which gave a 2:4 dinitrophenyl-hydrazone (brick red plates from ethyl alcohol, m.p. 234-235°C., is probably 4:4′-dichlorbenzophenone (described by Dittrich, *Annalen*, *264*, 177, as crystallising from ethyl alcohol in white leaflets of m.p. 144-145°C). Further, the oxime (needles from ethyl alcohol) had m.p. 135-136°C corresponding with the oxime of 4:4′ dichlorbenzophenone (Dittrich, *loc. cit.*, m.p. 135°C). Also, fusion of the oxidation product with caustic soda yielded an acid crystallising from water in small white needles, m.p. 235-236°C ; Beilstein and Schlun (*Annalen*, *133*, 243) give the m.p. of *p*-chlorbenzoic acid as 236°C. This evidence establishes that the chlorine atoms are in the para positions, the structure of the polychlorethane being :—



This compound was subsequently isolated from a sample of Gesarol, an identity confirmed by mixed melting point.

αα-bis (p-chlorphenyl) ββ-dichlorethylene $(C_6H_4Cl)_2\ C{=}CCl_2$: was prepared by heating the above polychlorethane with alcoholic caustic potash ; re-

TABLE III.

POLYCHLORETHANE DERIVATIVES AS STOMACH POISONS.

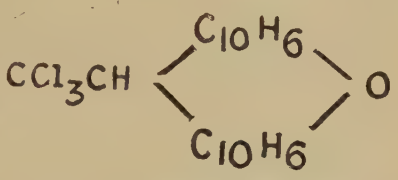
Test insect and No.	Time hr.	$(C_6H_5)_2$ $CH.CCl_3$	$(C_6H_4OH)_2$ $CH.CCl_3$	$(C_6H_4.O.COCH_3)_2$ $CHCl_3$	$(C_6H_4Cl)_2$ $CH.CCl_3$		Acetone
		5%	5%	5%	5%	0.5%	
M. brassicae:							
E 1	72	—	—	—	0/6 normal	—	5/5 normal
E 2	70	—	—	—	0/10 normal (0.8 disc)	0/8 normal (0.2 disc)	7/7 normal (1.1 disc)
E 3a	140	—	—	—	0/10 normal (negligible)	0/7 normal (0.11 disc)	5/5 normal
E 3b	140	—	—	—	0/2 normal (0.25 disc)	0/7 normal (0.16 disc)	(1.0 disc)
E 5a	48	—	—	—	—	0/6 normal (0.9 disc)	5/5 normal (1.2 disc)
E 5b	48	—	—	—	—	0/2 normal	1/1 normal
E 8a	48	—	7/7 normal (> 0.5 disc)	7/7 normal (0.4 disc)	—	0/7 normal (0.2 disc)	6/6 normal (0.8 disc)
E 8b	48	—	5/5 normal (0.6 disc)	5/5 normal (0.6 disc)	—	—	5/5 normal (0.8 disc)
E 12	48	—	—	4/4 normal (0.75 disc)	—	—	4/4 normal (0.75 disc)
E 15	72	—	—	—	—	0/6 normal (0.1 disc)	5/6 normal (1.8 disc)
E 17	72	3/4 normal (2.5 disc)	—	—	—	—	4/4 normal (2.25 disc)
Pionea:							
E 2	70	—	—	—	0/3 normal	1/2 normal	2/2 normal
E 36	140	—	—	—	—	0/1 normal	—
P. rapae:							
E 1	72	—	—	—	0/1 normal	—	1/1 normal
E 2	70	—	—	—	0/2 normal	—	1/1 normal
E 17	72	3/5 normal (0.2 disc)	—	—	—	—	3/3 normal (1.25 disc)
P. brassicae:							
E 12	48	—	—	3/4 normal (0.6 disc)	—	—	4/4 normal (0.5 disc)
E 15	72	—	—	—	—	1/6 normal (0.06 disc)	5/5 normal (0.8 disc)

crystallised from ethyl alcohol gave m.p. 88°C (Zeidler, *Ber.*, *7*, 1181) gives m.p. 89°C.

4:4′-*dichlorbenzophenone* $(C_6H_4Cl)_2C=O$, was obtained by oxidation of *bis* (*p*-chlorphenyl) trichlorethane, as described above. White leaflets, m.p. 143-144°C.

αα-bis (1-*hydroxynaphthyl*) *βββ-trichlorethane* $(C_{10}H_6OH)_2$ $CH.CCl_3$: from *α*-naphthol and chloral, crystallised from glacial acetic acid in transparent needles which became grey on keeping and blackened at 190-200°C. The corresponding diacetate $(C_{10}H_6O.CO.CH_3)_2$ $CH.CCl_3$, prepared by heating the derivative with excess of acetic anhydride and sodium acetate, crystallised in shining scales from ethyl alcohol and had m.p. 174-176°C; Rusanoff (*J. Russ. Chem. Soc. 23*, 217) gives m.p. 176°C.

αα-anhydro-bis(2-*hydroxynaphthyl*) *βββ-trichlorethane*, from *β*-naphthol and chloral, re-crystallised from chloroform in large tablets of m.p. 242-243°C. Rusanoff (*loc. cit.*) gives m.p. 236°C; Elbs (*J. pr.* (2), *47*, 66) gives 241°C.



Metachloral. A common by-product to the condensations described above was a white alcohol-insoluble amorphous solid, which was shown to be the metachloral described by Byasson, (*Compt. rend.*, *91*, 1071). On heating to 180-250°C it was reconverted into chloral (cf. Kolbe, *Annalen*, *54*, 183) and on prolonged standing in air it was converted to chloral hydrate. *Chloretone*, $CCl_3C(OH.)(CH_3)_2$; from acetone and chloroform by the action of powdered caustic potash as described by Willgerodt (*J.pr.* (2), *37*, 361). The compound had b.p. 167°C, and after re-crystallisation from methyl alcohol melted at 80-81°C.

The results obtained with these derivatives as stomach poisons and as contact insecticides are given in Tables III and IV respectively.

Discussion.

Of the various chloral condensation products examined, that with chlorbenzene is outstanding in its toxicity to the organisms tested. The onset of the reaction of the insect is slow but develops into an intense activity as if the compound caused irritation. This apparently unco-ordinated movement persisted for some hours but eventually ceased and, in the case of larvae, which exuded much fluid, the dead insect had shrunk to a fraction of its former size.

It is evident also that insecticidal properties are to some degree specific to the $ClC_6H_4CH(CCl_3).C_6H_4Cl$ molecule, though the range of analogous compounds tested is limited. Elimination of the hydrogen on the central carbon atom to give the corresponding ethylene derivative markedly reduced toxicity, and similarly, the dichlorbenzophenone only exhibited slight action.

Because of its high toxicity, no estimate of the M.L.D. of the *bis* (*p*-chlorphenyl) trichlorethane is possible, for even the robust *M. brassicae* larvae were killed by doses of the order of 0.01 mg. per larva (Exp. E5a, E 15) while the contact toxicity is of the same order. In view of the apparent harmlessness of this new insecticide to warm-blooded animals, it merits immediate field trials as a substitute for lead arsenate.

Metachloral, which is simultaneously produced if the condensation is carried out in sulphuric acid media, appears to be virtually non-toxic. Its relationship to metaldehyde prompted tests as a slug poison, but it proved useless for this purpose.

C. Substituted benzene derivatives.

Since the classical work of Tattersfield, Gimingham and Morris (1925) on the systematic examination of the insecticidal action of the chloro-, nitro- and hydroxyl derivatives of benzene and naphthalene, most of the simpler derivatives have been teated but few have been found to equal the potency of 3:5-dinitro-*o*-cresol. Most of the promising compounds are among the nitro-derivatives, and this group has received much attention especially with the objects of discovering insecticides less toxic to foliage and to warm-blooded animals than the dinitro-cresol (e.g. the acetate is reported less injurious to apple foliage by Smith 1942).

It has been found, however (Batt, Martin and Wain, 1944), that under certain conditions the nitrocresol is readily reduced, and it is necessary to know whether the reduction products possess insecticidal properties. The general effect of the substitution of amino groups for nitro groups in the simpler derivative has accordingly been examined.

A second line of work has arisen because, although the insecticidal properties of hydrogen cyanide and of aliphatic thiocyanates are known, little information is available of the properties of the simpler aromatic nitriles. As a number of these derivatives were available they were included in the tests for contact action, and those which showed some activity were tried as stomach poisons. The results of the tests are given in Tables V and VI.

Compounds used.

(a) *Nitro derivatives.*

3:5-*dinitro*-o-*cresol.* re-crystallised from alcohol m.p. 85-86°C.

3:5-*dinitro*-o-*tolyl acetate*: by heating the cresol with acetic anhydride and sodium acetate. Almost colourless plates from alcohol m.p. 95-96°C. Cazeneuve (*Compt. rend., 124,* 154) gives m.p. 95°C.

3-*amino*-5-*nitro*-o-*cresol*: by reducing the dinitrocresol with ammonium sulphide as described by Cazeneuve (*loc. cit.*). It crystallised from water in long red-brown needles m.p. 173-174°C (d). Cazeneuve gives m.p. 165°C (d).

1:3:5-*trinitrobenzene*: re-crystallised from alcohol, m.p. 121°C.

2:4:6-*trinitrophenol* (*picric acid*): m.p. 122°C.

m-*dinitrobenzene*: re-crystallised from alcohol, m.p. 88-89°C.

m-*nitraniline*: m.p. 114°C.

p-*nitraniline*: m.p. 146°C.

p-*chlornitrobenzene*: m.p. 83-84°C.

(b) *Cyano derivatives, etc.*

m-*dicyanobenzene*: by distilling potassium *m*-benzenedisulphonate with potassium cyanide as described by Barth and Senhofer (*Ber., 8,* 1481). Crystallised from amyl alcohol, m.p. 157-158°C; Barth and Senhofer give m.p. 156°C.

TABLE V.

SUBSTITUTED BENZENE DERIVATIVES AS CONTACT INSECTICIDES.

(*a*) Nitro-derivatives.

Organism and Test No.	Time hr.										Carrier alone
		5%	5%	5%	5%	5%	5%	5%	5%	5%	
FORFICULA spp.											
B 6	48	—	—	—	—	—	—	—	—	0/11 normal	12/12 normal
B 7	48	—	—	—	—	—	—	9/9 normal	7/7 normal	—	9/9 normal
B 8	48	—	—	—	13/14 normal	15/15 normal	5/17 normal	—	—	—	12/12 normal
B 9	48	0/10 normal	4/10 normal	9/10 normal	—	—	—	—	—	—	9/10 normal
WOODLICE.											
C 5	48	—	—	—	—	—	—	—	—	0/10 normal	35/35 normal
C 6	48	—	—	—	17/21 normal	0/14 normal	2/17 normal	18/19 normal	1/20 normal	—	14/14 normal
C 7	48	0/14 normal	0/17 dead	13/13 normal	—	—	—	—	—	—	16/16 normal

(*b*) Cyano-derivatives, etc.

Organism and Test No.	Time hr.									Carrier alone
		5%	5%	5%	5%	5%	5%	5%	5%	
M. BRASSICAE.										
E 13*a*	72	7/8 normal	8/8 normal	5/6 normal	5/6 normal	8/8 normal	6/6 normal	—	—	4/6 normal
E 13*b*	72	—	—	4/4 normal	4/4 normal	—	4/4 normal	—	—	4/4 normal
FORFICULA spp.										
B 6	48	—	—	—	—	—	—	13/13 normal	6/10 normal	12/12 normal
B9	48	—	—	—	—	—	10/12 normal	—	—	9/10 normal
WOODLICE.										
C 4	48	13/15 normal	23/24 normal	27/31 normal	3/21 normal	1/18 normal	5/13 normal	—	—	12/13 normal
C 5	48	—	—	—	—	—	—	12/12 normal	6/17 normal	35/35 normal
C 6	48	—	—	—	—	—	—	14/18 normal	6/16 normal	14/14 normal
C 7	48	—	—	—	—	—	0/15 normal	—	—	16/16 normal

TABLE VI.

SUBSTITUED BENZENE DERIVATIVES AS STOMACH POISONS.

1 disc ≡ 1 mg. insecticide.

Organism and Test No.	Time hr.							Acetone.
		5%	5%	5%	5%	5%	5%	
M. BRASSICAE.								
E 2	70	10/11 normal (0.1 disc)	—	—	—	—	—	7/7 normal (1.1 disc)
E 12	48	—	—	—	4/4 normal (0.8 disc)	—	—	4/4 normal (0.8 disc)
E 15	72	—	—	—	6/6 normal (1.8 disc)	—	—	5/6 normal (1.8 disc)
E 17	72	—	—	5/5 normal (1.8 disc)	—	4/4 normal (2.0 disc)	4/4 normal (1.5 disc)	4/4 normal (2.25 disc)
E 19	72	3/4 normal (negligible)	4/4 normal (1.25 disc)	—	—	—	—	4/4 normal (1.0 disc)
PIONEA.								
E 2	70	2/2 normal	—	—	—	—	—	2/2 normal
P. RAPAE.								
E 2	70	0/1 normal	—	—	—	—	—	1/1 normal
E 17	72	—	—	4/4 normal (0.4 disc)	—	3/3 normal (1.1 disc)	4/4 normal (0.25 disc)	3/4 normal (1.25 disc)
E 19	72	5/6 normal (negligible)	6/6 normal (0.4 disc)	—	—	—	—	5/5 normal (0.6 disc)
P. BRASSICAE.								
E 12	48	—	—	—	3/4 normal (0.6 disc)	—	—	4/4 normal (0.5 disc)
E 15	72	—	—	—	6/6 normal (0.3 disc)	—	—	5/5 normal (0.8 disc)

3:5-*dicyanonitrobenzene*: from 5-nitro-*iso*-phthalic acid as described by Bennett and Wain (*J.C.S.* 1936, 1111). Small needles from amyl alcohol m.p. 203-205°C.

3:5-*dinitrocyanobenzene*: from 3:5-dinitrobenzoic acid as described by Bennett and Wain (*loc. cit.*) Yellow prisms from alcohol, m.p. 128.5°C.

m-*bromcyanobenzene*: from *m*-bromonitrobenzene by reduction followed by diazotisation and treatment with cuprous cyanide. Colourless needles from petroleum ether m.p. 37-38°C; Schopff (*Ber.*, *23*, 3437) gives m.p. 38°C.

m-*chlorcyanobenzene*: from *m*-chlornitrobenzene by the method described above. Light brown needles from petroleum ether, m.p. 41-42°C; Griess (*Ber.*, *2*, 370) gives m.p. 39°C.

p-*tolyl cyanide*: from p-toluidine by the method of Sandmeyer (*Ber.*, *17*, 2653.) b.p. 218°C, m.p. 28°C.

p-*chlorbromobenzene*: m.p. 66-67°C.

p-*dibromobenzene*: m.p. 86-87°C.

Discussion.

As was expected, dinitro-*o*-cresol showed marked contact toxicity. Its failure to kill in the stomach poison test is to be ascribed to its deterrent action, for the amount taken by the test larvae was negligible. The acetate shows the contact insecticidal properties of the cresol, but the reduction of one of the nitro groups leads to a loss of both contact and deterrent properties. A similar effect is shown in *m*-dinitrobenzene, the substitution of one nitro group by the amino group to give *m*-nitraniline resulting in a loss of toxicity. Bushland (1940), who examined the action of many organic compounds on the screw-worm *Cochliomyia americana* C. and P., concluded that the introduction of a primary amino group greatly reduced or destroyed toxicity. On the other hand Tattersfield and Gimingham (1927) found *o*-nitraniline of high contact toxicity to *Aphis rumicis*, being unable to test the *m*- and *p*-nitranilines because of their low solubility. Neither showed promise in Bushland's trials nor in the few tests of Table V, though the substitution of the amino group of the latter by chlorine gave a compound, *p*-chlornitrobenzene, of high contact toxicity but exhibiting no stomach poison effect. This derivative was found by Bushland (1940) to be as toxic as thiodiphenylamine to screw-worm larvae. Bushland also reported 1:3:5-trinitrobenzene to be of the same order of toxicity and the corresponding phenol, picric acid, to be slightly less toxic. Neither compound proved toxic to earwigs (Table V).

The cyano-derivatives tested showed no promise as contact insecticides, though it was noted that *p*-tolyl cyanide rapidly paralysed both earwigs and woodlice, though most recovered within the period of the test.

D. Aliphatic Thiocyanates and Nitriles.

The aphicidal and ovicidal properties of dodecyl and butyl carbitol thiocyanates are well-known and evidence was required of their properties as stomach insecticides. The related dodecyl nitrile and other higher fatty nitrilles have been shown by Ralston and Barrett (1941) to be repellent to flies. We are indebted to Messrs. Armour & Co., of Chicago, for samples of the latter products, N120 being described as a mixture of about 90% dodecyl nitrile and 10% tetradecyl nitrile; ND 181 5-C being a mixture of approximately 60% octadecyl, 25% octadecadienyl, and 15% hexadecyl nitrile.

The results obtained are summarised in Table VII and show that the thiocyanates are deficient in stomach poison properties. The two nitriles are non-toxic, but exhibit some degree of deterrent action when present in relatively high concentration.

E. Miscellaneous Compounds.

Thiuram Sulphides: Guy (1936) reported that tetramethylthiuram disulphide, applied to host foliage prevented various leaf-eating insects from feeding. Larvae of *M. brassicae* were, however, found to take leaf sandwiches treated with either tetramethylthiuram monosulphide or disulphide without toxic symptoms developing, though the average amount consumed per larva was slightly lower, 0.6 disc and 0.75 disc respectively, than of acetone-lanolin treated sandwiches (1.0 disc).

Thiodiphenylamine: Siegler, Munger and Smith (1936) examined thiodiphenylamine (phenothiazine) as a substitute for lead arsenate and found its initial toxicity to Codling Moth larvae higher than that of the arsenates. Tests of the pure chemical showed it to be virtually non-toxic to *M. brassicae* caterpillars, 4/5 remaining normal after eating 2.1 discs = 2.1 mg. thiodiphenylamine per larvae (E 15). With larvae of *P. brassicae*, however, there was negligible feeding and only 3 out of 9 larvae remained unaffected after 72 hr. (E 15).

Salicylaldehyde: It is possible that salicylaldehyde, excreted by larvae of *Phyllodecta vitellinae* L. (see Wain, this report, p. 108) serves to repel other insects. Tests showed that larvae of *M. brassicae*, of *Pionea forficalis*, L. and of *P. rapae* took sandwiches prepared with salicylaldehyde and survived.

Crystox: This is the trade name of a condensation product of isophorone which, it is claimed, promotes the insecticidal activity of the pyrethrins. Tested by itself in sandwiches containing 1 mg. it proved non-toxic and non-repellent to larvae of *M. brassicae* and of *P. rapae*.

SUMMARY.

Qualitative tests for the examination of stomach poisons, contact insecticides and repellents (insectifuges) are described.

It is shown that, against the insects tested :—

1. Rotenone and rotenone-containing insecticides have little contact insecticidal action and, as stomach poisons, are specific in action, being toxic to *Pieris* larvae at concentrations far below those tolerated by *Mamestra* larvae, against which some repellent action is shown.

2. Of certain polychlorethane derivatives, *αα-bis* (*p*-chlorphenyl)-*βββ*-trichlorethane, has a marked potency both as stomach poison and contact insectide.

3. Dinitro-*o*-cresol exhibits pronounced contact toxicity and deterrent action, but reduction of one of the nitro groups leads to a loss of both contact and repellent properties.

4. Dodecyl thiocyanate and butyl carbitol thiocyanate are deficient in stomach poison properties, while dodecyl nitrile is non-toxic but shows slight repellent properties.

5. The thiuram sulphides tested are non-toxic but slightly repellent.

TABLE VII.

ALIPHATIC NITRILES AND THIOCYANATES AS STOMACH POISONS.

Test Insect and No.	Time hr.	N 120.		ND 181.		Dodecylthiocyanate		Butylcarbitol thiocyanate.		Acetone.
		100%	5%	100%	5%	10%	5%	7.5%	4%	
M. brassicae :										
E 8a	48	6/6 normal (0.1 disc)	—	5/5 normal (0.2 disc)	—	—	—	—	—	6/6 normal (0.8 disc)
E 8b	48	—	—	5/5 normal (0.4 disc)	—	—	—	—	—	3/3 normal (1.3 disc)
E 10	48	—	4/4 normal (1.5 disc)	—	4/4 normal (0 75 disc)	—	—	—	—	4/4 normal (1.0 disc)
E 11	48	—	3/4 normal (1.5 disc)	—	4/4 normal (1.5 disc)	—	2/2 normal (1.75 disc)	—	4/4 normal (1.1 disc)	4/4 normal (1.5 disc)
E 15	72	—	—	—	—	2/6 normal (1.5 disc)	—	1/6 normal (1.1 disc)	—	5/6 normal (1.8 disc)
P. brassicae :										
E 15	72	—	—	—	—	3/9 normal (negligible)	—	5/7 normal (negligible)	—	5/5 normal (0.8 disc)

6. Thiodiphenylamine (phenothiazine) is highly repellent to *Pieris* larvae but has no action on *Mamestra* larvae.

REFERENCES.

Batt, R. F., Martin, H., and Wain, R. L. (1944). The use of toxic polynitro derivatives in pest control. II. The estimation of dinitro-*o*-cresol in winter washes. *Ann. appl. Biol. 31*, 64).

Bushland, R. C. (1940). The toxicity of some organic compounds to young screw-worms. *J. econ. Ent., 33*, 669.

Campbell, F. L. (1926). The practicability of quantitative investigations on mandibulate insects. *J. agric. Res., 32*, 359.

Campbell, F. L., and Filmer, R. S. (1929). A quantitative method of estimating the relative toxicity of stomach-poison insecticides. *Trans. IV. Internat. Cong. Ent.* for 1928, 523.

Griffiths, J. T., and Tauber, O. E. (1943). Evaluation of sodium fluoride as a stomach poison and as a contact insecticide against the roach *Periplaneta americana* L. *J. econ. Ent., 36*, 536.

Guy, H. G. (1936). Thiuram sulphides as repellents to leaf-eating insects. *J. econ. Ent., 29*, 467.

Martin, H. (1943). The evaluation of fungicides : a study in quantitative toxicology. *J. Soc. chem. Ind., 62*, 67.

McIndoo, N. E. (1916). Effects of nicotine as an insecticide. *J. agric. Res., 7*, 89.

Morrison, F. O. (1943). The standardization of a laboratory method for comparing the toxicity of contact insecticides. *Canad., J. Res., 21*, Sec. D., 35.

Parker, E. A., and Green, A. A. (1943). A film technique for the biological evaluation of pyrethrum-in-oil insecticides for use against stored product insects in warehouses. *Ann. appl. Biol., 30*, 279.

Ralston, A. W., and Barrett, J. P. (1941). Insect-repellent activity of fatty acid derivatives. *Oil and Soap, 18*, 89.

Richardson, C. H., and Shepherd, H. H. (1930). The effect of hydrogen-ion concentration on the toxicity of nicotine, pyridine and methyl-pyrrolidine to mosquito larvae. *J. agric. Res., 41*, 337.

Shafer, G. D. (1915). How contact insecticides kill. Part III. *Tech. Bull. Mich. agric. Exp. Sta.*, 21.

Siegler, E. H., Munger, F., and Smith, L. E. (1936). Laboratory tests of phenothiazine against codling moth larvae. *J. econ. Ent., 29*, 532.

Smith, L. E. (1942). Synthetic organic compounds as potential insecticides. *Industr. engng. Chem., 34*, 499.

Speyer, E. R., Read, W. and Orchard, O. (1939). Pests of vegetables. *Rep. Exp. Res. Sta. Cheshunt*, p. 39.

Sweetman, H. L. (1941). Tests for toxicity of arsenicals and sodium fluoride to the American roach *Periplaneta americana*. *Canad. Ent., 73*, 31.

Swingle, M. C. (1934). Differences in action of derris and pyrethrum against the imported cabbage worm shown by experiments with gelatine films containing these plant materials. *J. econ. Ent., 28*, 1101.

Tattersfield, F. (1939). Biological methods of testing insecticides. *Ann. appl. Biol., 26*, 365.

Tattersfield, F., and Gimingham, C. T. (1927). Studies on contant insecticides. Part V. The toxicity of the amines and *N*-heterocyclic compounds to *Aphis rumicis* L. *Ann. appl. Biol., 14*, 217.

Tattersfield, F., Gimingham, C. T., and Morris, H. M. (1925). Studies on contact insecticides. III. A quantitative examination of the insecticidal action of the chlor-, nitro- and hydroxyl derivative of benzene and naphthalene. *Ann. appl. Biol., 12*, 218.

Tattersfield, F., and Potter, C. (1943). Biological methods of determining the insecticidal values of pyrethrum preparations (particularly extracts in heavy oil). *Ann. appl. Biol., 30*, 259.

THE USE OF COPPER SEBACATE AS A FOLIAGE SPRAY.

By R. W. MARSH.

In the laboratory tests carried out by Martin, Wain and Wilkinson (1942) copper sebacate showed a fungicidal value greater than that of Bordeaux Mixture of the same copper content. Preliminary trials by Wain and Wilkinson (1943) demonstrated the value of copper sebacate as a seed dressing for peas and showed that a suspension of the sebacate in water sprayed on to tomato plants in the field gave adequate cover and left a tenacious non-phytocidal deposit. Owing to the non-appearance of Blight in this trial the protective value of the spray could not be assessed.

Methods of Compounding.

In continuing these trials in 1943, experiments were made in compounding the sebacate to a form which would disperse readily in water to yield a stable suspension. The mixture of sebacate with water used in 1942 was obtained after a prolonged grinding process which would not be practicable for general field work. It was found that mixtures of sebacate with bentonite or with saponin did not produce satisfactory suspensions, but that sebacate mixed dry with the requisite weights of either Agral II or sulphite lye powder and subsequently added to water readily dispersed to a finely-divided suspension of satisfactory stability. The proportion of sebacate to wetter had to be such that on dilution the copper content of the spray, the stability of the suspension and its wetting power should all be adequate for the spray treatment required. These conditions were met by a mixture of 4 lb. copper sebacate with 2 lb. Agral II in 100 gallons of water. The copper sebacate required for the 1943 trials was kindly prepared by Dr. Wain: this was added to one-half its weight of Agral II and the material was intimately mixed by rotation in a ball mill for one hour. The mixture was kept dry and used when needed at 6 lb. to 100 gallon water (*i.e.* 0.1% Cu, 0.2% Agral II, by weight).

Field trials were made with this copper sebacate-Agral spray in 1943 on onions, tomatoes and black currants.

Trials on Onions.

Bedfordshire Champion onions at two field sites in Worcestershire and one in Somerset were sprayed with the sebacate-Agral mixture in comparison with other sprays including Bordeaux Mixture 8–12–100 to which Agral II was added at the rate of 2 lb. per 100 gallons. The dates of spraying were June 21 and July 14 in Worcestershire, July 13 and August 3 in Somerset. Applications were made at the rate of 600 gallons per acre, using a knapsack outfit fitted with two fine nozzles. Satisfactory wetting of the waxy foliage of the onions was obtained with both the sebacate and the

Bordeaux sprays and no damage resulted. Estimates of copper retention were made for each treatment on 50 leaf discs of 1.4 cm. diam., with the following results :—

Results of Estimates of Cu Retention on Onion Leaves.

Spray applied.	Mgm. Cu 4 hrs. after spraying.	Mgm. Cu 14 days after spraying.
Sebacate–Agral	0.21	nil
Bordeaux–Agral	0.59	0.32

The difference in initial retention, shown in the first column, is largely accounted for by the fact that the sebacate spray was applied at 0.1 % Cu, while the Bordeaux contained 0.2%. The figures on tenacity demonstrate that the Bordeaux–Agral spray was much superior to the sebacate–Agral in resistance to weathering on onion foliage.

The sprays were applied for the control of Onion Downy Mildew (*Peronospora Schleideniana*), but in the Worcestershire trials drought supervened and the disease did not appear. On the Somerset site, a very heavy infection developed which was not controlled by any of the treatments employed.

Trial on Tomatoes.

The copper sebacate–Agral mixture used at a concentration of 0.1% Cu was applied on July 29 to six varieties of tomatoes at Long Ashton. This spraying formed part of a comparative trial of five copper fungicides against Tomato Blight, details of which are given by Mr. Croxall elsewhere in this Report. The sebacate was applied with a barrow pump at a rate equivalent to 600 gallons per acre. Owing to shortage of material no subsequent spraying with copper sebacate was given, but the plots treated with the other fungicides received a second spraying in mid-August. The single spraying with copper sebacate resulted in an increase of 50% in the crop of blight-free tomatoes, as compared with that from the control plots. No injury was caused and there was no apparent deposit on the fruits at the time of picking. Full details are given in Mr. Croxall's paper.

Trial on Black Currants.

A block of 48 Baldwin bushes was sprayed on August 6 as follows :— (*a*) one-third with copper sebacate–Agral at 0.1% Cu, (*b*) one-third with 4–6–100 Bordeaux plus Agral II at 2 lb. per 100 gallons as in (*a*), and (*c*) one-third unsprayed. The treatments were replicated along the row in the order, Bordeaux, control, sebacate, on successive bushes. Spraying was done by knapsack at the rate of approximately half-gallon per bush. Defoliation due to Black Currant Leaf Spot was starting when the sprays were applied and the degree to which the disease was checked by spraying is indicated by the leaf retention figures recorded on September 10 and October 4 as under :—

Mean Percentage Foliage Retention.

Treatment.	Sept. 10.	Oct. 4.
Sprayed with Bordeaux mixture	59	45 ± 5
,, ,, Sebacate	65	54 ± 5
Unsprayed	32	11 ± 2

The difference between the results from the two copper sprays is not significant, but the trial demonstrated that the sebacate spray was at least as efficient as Bordeaux in the control of Black Currant Leaf Spot.

Discussion.

The field performance of a fungicide is the resultant of two factors (1) the quantity of protectant remaining on the plant, (2) the fungicidal value of this residue (Horsfall, Marsh & Martin, 1937). Thus it is possible to some extent to compensate for low fungicidal value by methods of compounding which confer high initial retention and tenacity on the fungicidal material. For example, a number of the copper fungicides now in general use in this country are based on cuprous oxide and copper oxychloride, neither of which is of outstanding fungicidal value (Martin, Wain and Wilkinson, 1942). Nevertheless, these have been compounded to products of field performance frequently equal to that of Bordeaux Mixture. If a material of higher fungicidal value, such as the sebacate, could be prepared in a form conferring adequate initial retention and tenacity, it is reasonable to infer that it could be used successfully at a lower copper concentration than the oxides or oxychlorides. This advantage would then obviously have to be weighed against the disadvantage of higher cost of manufacture.

The trials reported in this paper were severely restricted by the fact that copper sebacate is not in commercial production, and only a small quantity (approximately 4 lb.) could be made available for field trials in 1943. Therefore it was impossible to test any range of strengths and all the field work with the sebacate was done with sprays having an arbitrary concentration of 0.1% Cu. In making up the sebacate sprays it was found necessary to use a high concentration (0.2%) of Agral II in order to secure the necessary stability of suspension. Experimental mixtures were made up with 0.1% and 0.05% of Agral, but at these lower strengths the stability of the spray was decreased. Mixtures with less than 0.2% Agral could be used in power sprayers equipped with efficient agitators, but were not suitable for hand-operated outfits.

The effect of the high wetter concentration was, as shown in the onion trials, to reduce seriously the tenacity of the sebacate deposit, although this adverse effect was much less marked on the Bordeaux residue. In the circumstances it is surprising that the sebacate spray exerted such a measure of control in the trials against Tomato Blight and Black Currant Leaf Spot. In the latter trial, the only one in which the sebacate and Bordeaux Mixture were used at the same copper concentration, the field performance of the sebacate was at least equal to that of the Bordeaux. The inference is that

the relatively small residue left after the weathering of the sebacate spray was of equivalent fungicidal value to the much heavier residue from the Bordeaux Mixture.

It is concluded that copper sebacate shows promise of satisfactory field performance and, provided that it can be compounded in a form which will ensure stability of suspension without unduly reducing tenacity, it should prove a valuable addition to the range of protectant fungicides.

Summary.

1. Copper sebacate mixed dry with half its weight of Agral II readily forms a stable suspension suitable for spraying.

2. The sebacate–Agral spray, used at 0.1% Cu and 0.2% Agral, was inferior in tenacity to a comparable Bordeaux–Agral spray but not inferior in controlling Leaf Spot of black currants.

Acknowledgment.

The author is much indebted to Mr. C. J. Hickman of the Field Laboratory at Evesham for assistance in carrying out the onion spraying trials.

REFERENCES.

(1) Croxall, H. E. (1944). Trials on the control of blight in outdoor tomatoes. *Long Ashton* 1943 *Ann. Rept.*, 95-99.

(2) Horsfall, J. G., Marsh, R. W. and Martin, H. (1937). Studies upon the copper fungicides. IV. The fungicidal value of the copper oxides. *Ann. Appl. Biol.* 24, 867-882.

(3) Martin, H., Wain, R. L. and Wilkinson, E. H. (1942). Studies upon the copper fungicides. V. A critical examination of the fungicidal value of copper compounds. *Ann. Appl. Biol.* 29, 412-438.

(4) Wain, R. L. and Wilkinson, E. H. (1943). A preliminary trial of new copper fungicides on outdoor tomatoes. *Long Ashton* 1942 *Ann. Rept.*, 56-58.

BITTER ROT OF APPLES CAUSED BY *GLOEOSPORIUM ALBUM* OSTERW, WITH SPECIAL REFERENCE TO THE VARIETY ALLINGTON PIPPIN.

By E. H. WILKINSON.

1. Introductory.

A study of the lenticel rotting of apples was carried out during 1937-39 when large numbers of many commercial varieties were collected from Somerset, Kent, Cambridgeshire, Worcestershire, Herefordshire and Cheshire and cold stored at Long Ashton. As a result it was shown that four different fungi were responsible for the occurrence of lenticel rots, viz.: *Cylindrocarpon mali* (Allesch.) Wr., *Gloeosporium fructigenum* Berk., *G. perennans* Z. & C., and *G. album* Osterw. The first three species occurred only occasionally, but *G. album* was isolated consistently and proved to be the major cause of lenticel rots during these investigations.

G. album was first recorded in Switzerland in 1907 by Osterwalder (18), causing late storage rots and was later described by Schneider-Orelli (20) as the most important rot-producing fungus in that country. Marchal and Marchal (16) also found it a common storage trouble in Belgium. Kidd and Beaumont (13) recorded the disease in England in 1924, causing slight damage to stored apples while in 1935 Ogilvie reported its occurrence on the increase (17). Finally in 1941 Osterwalder (19) found it attacking Glocken apples in Switzerland.

In England the disease in known as Bitter Rot (2), having been reported most years during the past decade as not uncommon on stored fruit (4), and is apparently restricted to the genus *Pyrus*. Besides attacking all varieties of apples examined by the writer it has been recorded on pear fruits by Kidd and Beaumont (13) and on quince in Hertfordshire (3). Grove (8) records it attacking fruits of *Pyrus communis*, *P. malus* and *P. cydonia*. *G. album* was also found by Ogilvie (17) existing saprophytically on dead pruning snags of apples trees.

2. The Disease.

(i) *On apple fruits.*

Bitter Rot usually appears in storage during the latter part of November, but it has been observed attacking Allington Pippin apples on the tree in mid-October. Its development is essentially the same on all varieties examined, starting as a pale-brown or purple marking of the lenticular tissues and the skin immediately adjacent. At the end of the first stage of radial expansion the lesions are a uniform brown in colour and no more than 3-5 mm. in diameter, each having a lenticel at its focus. Radial development continues slowly until lesions of 8—50 mm. in diameter are formed, the size depending upon the number of separate infections on each fruit. The lesions are circular, flattened or concave, skin smooth, the margins sharply defined with light brown centres

surrounded by a darker brown marginal zone. Occasionally rots are seen with two sets of light and dark brown bands or a uniform colour showing no zonation.

Sporing bodies originate sub-epidermally, causing the overlying skin to be raised in numerous small pimples. These eventually burst through the skin to become exposed as small white wax-like bodies which, in mature rots, are arranged concentrically around the central lenticel (Plate I) and liberate white masses of spores embedded in a mucilaginous matrix.

Bitter Rot caused by *G. album* can be distinguished from lenticel rots formed by *G. perennans* Z. & C. by spore examination only (23).

The number of Bitter Rot lesions on a single fruit varies considerably from one, on such varieties as Bramley's Seedling, to more than 200 on terminal fruits of Allington Pippin.

(ii) *On apple twigs.*

In the orchard the fungus is present on small dead twigs and pruning snags. Ogilvie (17) found it forming small cankers but the writer never observed this symptom. The only certain method of detecting its presence is by incubating suspected snags in moist conditions and observing the exudation of glutinous white masses of spores over their surfaces. The fungus was found frequently, using this method, on pruning snags of Worcester Pearmain, Bramley's Seedling and Allington Pippin in the orchards at Long Ashton.

(iii) *Economic importance.*

A Swiss publication (1) states that apples stored between 4° and—1°C. during 1929-30 and 1930-31 were infected to the extent of 67.9% and 85.1% respectively by *G. album*. During 1937-38 the writer examined 21,600 apples representing all the popular commercial varieties and found 15.41% of the fruits infected with Bitter Rot. Likewise, in 1938-39, 12,822 apples showed an infection of 8.16%. The identity of *G. album* was established for each rot by examination of the spores on the lesions or by isolation from the rotted tissues of non-sporing lesions. The incidence of Bitter Rot caused by *G. album* is compared with that of Grey Mould (*Botrytis cinerea* Fr.) and Blue Mould (*Penicillium expansum* Thom.) during the same two storage seasons (Table I).

TABLE I.

Intensity of Bitter Rot, Grey Mould and Blue Mould on apples during two storage seasons.

Disease.	1937—38.			1938—39.		
	No. apples examined.	No. apples infected.	% infection.	No. apples examined.	No. apples infected.	% infection.
Bitter Rot	21,600	3,328	15.41	12,822	1,046	8.16
Grey Mould ..		1,417	6.56		1,034	8.08
Blue Mould		715	3.31		952	7.42

Counts made in 1937-38 suggest that the incidence of attack of Bitter Rot depends upon the variety, dessert fruits being more susceptible than culinary :

Worcester Pearmain ..	46%	Grenadier	15%
Cox's Orange Pippin ..	38%	Bramley's Seedling ..	3%
Laxton's Superb	8%	Newton Wonder	2%

(iv) *Methods of attack.*

Under storage conditions *G. album* attacks apples through the lenticels, but occasionally it has been observed causing rots around all types of skin fractures. The most important point of entry to apple tissue other than through lenticels is around the margins of Scab (*Venturia inaequalis*) lesions. For example, in the 1938-39 storage season 2,124 Worcester Pearmain fruits in Somerset were infected to the extent of 7.8% by this means alone.

3. Experimental.

(i) *Isolation of fungus and growth in culture.*

Monoconidial isolations of *G. album* from Bitter Rot lesions and infected twigs were obtained by agitating fruiting bodies in sterile distilled water and placing the suspensions on plates of 2% malt-extract agar. Both isolations behaved alike on this agar, the optimum temperature for growth being 23° C, but even so growth at this temperature is slow, the thalli measuring only 30 mm. in diameter after 23 days. The isolations formed a convex mound of white mycelium creating a depression in the agar around their margins with subsequent distortion and cracking of the medium beneath the colonies. The white colour is retained for some time, but with age the mycelium assumes a ragged woolly appearance, finally becoming dirty-white in colour. No discolouration of the agar was observed. Acervuli are produced after 28 days as compact masses of pseudoparenchymatous tissue which become modified to form a concave sporing layer. Spore production is continuous by means of terminal phialospores, accumulating over the acervuli as pale cream or white masses or tendrils embedded in a mucilaginous matrix. The conidiophores are hyaline, variable in length, mostly shorter than the spores, 10-15μ x 3-4μ, and occasionally branched at the base. The spores are hyaline, cylindrical, rounded at both ends, mostly curved or sickle-shaped, each having a single, clear vacuole-like area in the centre. Measurements of spores taken respectively from cultures on two types of media, and from Bitter Rot and infected twigs are given below :—

Bitter Rot of Bramley's Seedling ..	12-27$\mu\times$3-4.5μ	(Mean : 21.5$\times$3.3μ)
Bitter Rot (Malt-extract agar) ..	15-27$\mu\times$3-4.5μ	(Mean : 21.4$\times$3.2μ)
Bitter Rot (Wheatmeal agar) ..	9-33$\mu\times$2.3-4.5μ	(Mean : 23.7$\times$3.1μ)
Infected pruning snags of Allington Pippin	16-27$\mu\times$3-3.7μ	(Mean : 21.6$\times$3.1μ)

Osterwalder (18) gives measurements of 24$\times$3μ.

(ii) *Apple inoculations.*

(*a*) *Through injured skin.* Apples of the variety Annie Elizabeth were inoculated by hinging back a flap of skin, inserting the inoculum and replacing the skin, the wounds being smeared over with a thin film of medicinal vaseline.

Control wounds left uninoculated were also made. The following types of inoculum were used :—

Mycelium from culture of Bitter Rot of apple ;
Mycelium from fungus isolated from infected twigs ;
Spores from surface of Bitter Rot ;
Spores from surface of infected twig.

The apples were retained in moist chambers at laboratory temperatures. After 7 weeks all inoculations had produced rots and those formed from mycelium and spores of the fungus infecting pruning snags were identical with those formed from mycelium and spores of the Bitter Rot fungus. Most of the rots produced acervuli after 35 days, and from the spores and rotted tissues pure cultures of *G. album* were obtained.

(*b*) *Through lenticels.* Ten lenticels each on single fruits of Bramley's Seedling and King Edward VII were inoculated by fixing small glass tubes vertically to their surface with vaseline so that a single lenticel was enclosed by the attached end of each tube. A small volume of a spore suspension of *G. album* was pipetted into each tube so that no air lock was formed between the suspension and the apple skin. After 8 weeks no lenticel rots had developed.

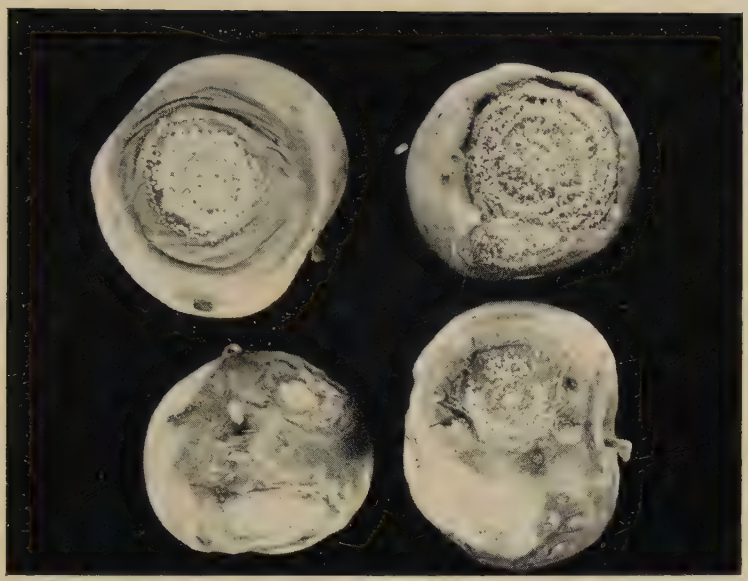
A similar experiment was made using the varieties Allington Pippin, Cox's Orange Pippin and King Edward VII. One apple of each variety was treated with the vapour from a 7.5 N (14%) ammonia solution for 15 minutes, while a similar number were left untreated. Eight tubes were fixed over single lenticels on each apple of both treatments and supplied with a spore suspension of *G. album* before being placed in moist chambers for observation. After 17 days the inoculated lenticels on the untreated apples were unaffected. Those fruits which had been subjected to ammonia vapour showed 4 of the treated lenticels on the Allington Pippin fruit with slight areas of browning up to 1.5 mm. in diameter. Isolations from these spots failed to reveal the presence of *G. album*. All other treated lenticels remained unchanged.

(*c*) *Through scab lesions.* Apples showing well-developed Scab (*Venturia inaequalis*) lesions were inoculated with a spore suspension of *G. album*. This treatment was applied to 19 selected lesions (those showing no visible transverse or marginal cracks) whose surfaces were gently stroked to ensure complete contact between the lesions and the suspension. The fruits were retained in moist chambers at laboratory temperatures. After 21 days no signs of rotting were evident around the margins of the lesions.

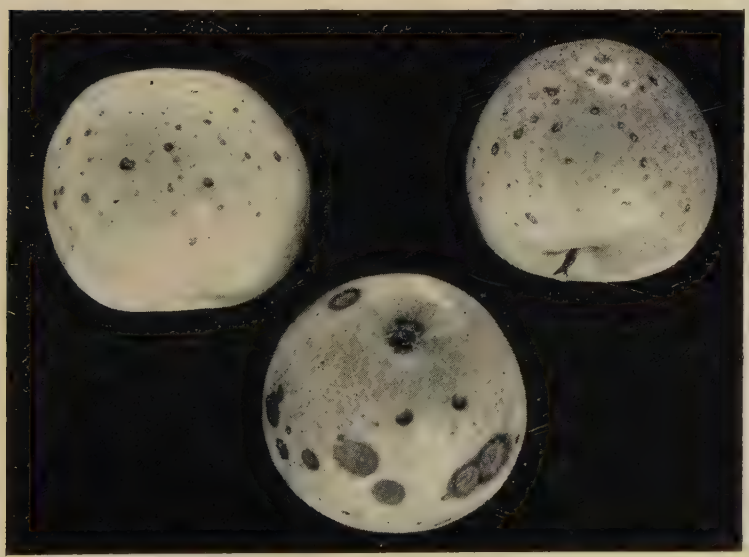
Ten similar Scab lesions were inoculated by placing a square of inoculum so that the mycelium made close contact with each lesion. After 21 days, in a moist chamber, 7 of the treated lesions developed marginal rots, all of which yielded pure cultures of *G. album*. Fifteen untreated lesions on the same fruits failed to develop rot.

(iii) *Branch inoculations.*

Two-year-old living branches of Bramley's Seedling were cut back to within 2-3 in. of the main branch and killed by gently heating with an alcohol flame. Each of the four types of inoculum detailed above was inserted under the bark of five treated twigs respectively, all inoculations being bound with a crêpe-rubber bandage. Cuts in healthy twigs were also inoculated and controls of both types made.



I.—Bitter Rot of apples caused by *G. album*. Advanced stage showing concentric rings of acervuli.



II.—Lenticel spotting of Allington Pippin (Allington Spot)

(a) upper two apples : early stage of the disease ;

(b) lower apple : development of Bitter Rot from lenticel spots after 21 days.

Negative results were obtained from all inoculations on the killed twigs owing to saprophytic fungi invading the dead tissues. The controls were also contaminated. No infection occurred in living twigs, and after 15 weeks the wounds had callused over.

In the laboratory 6 in. lengths of 2-year-old apple branches, previously killed by steam sterilisation, were placed with one cut surface in contact with cultures of *G. album* growing on malt-extract agar. After 10 weeks the portion of the branches in contact with the isolations were examined. The fungus had grown beneath the bark and formed small cushions of interwoven mycelium. In section their structure and shape suggested rudimentary acervuli, but those allowed to develop failed to produce spores. Isolations from fragments of these cushions gave pure cultures of *G. album* which produced typical rots when inoculated into apples.

4. *G. album* in relation to lenticel spotting of Allington Pippin.

Lenticel spotting of stored apples has been reported in England and U.S.A. for the past 30 years, and reference to the literature relating to this disease indicates that opinions vary as to its origin. Barker (5), Spinks (22), Horne (11, 12), and Horne and Horne (9, 10) suggested that the spots are formed mainly by direct penetration of the lenticels by various pathogenic fungi, whereas Scott and Roberts (21), Brooks and Cooley (6) and Kidd and Beaumont (14), who named the disease Lenticel Spot, gave evidence that the initial stages were the result of functional disorders which later permitted the entrance of fungi to produce rots. Support to this second theory was given by Kidd and West (15), who demonstrated that aromatic esters from early maturing varieties induced lenticel spots on later maturing varieties, and similar spotting was also induced when ethylene at 1/500 was used. Rots subsequently developed from these artificially produced spots.

In England fruits of the variety Allington Pippin suffer from a serious lenticel spot disease (Plate II, upper two apples), to which the name Allington Spot has been given (4), the spots eventually developing into circular lenticel rots as shown in the lower apple (Plate II). Detailed observations of this disease were made by the writer on samples of spotted fruits obtained from different localities. In all, 113 apples were examined, and of these 79% were terminal or " King " fruits indicating that the disease appears more readily on these fruits than on laterals. This point has been supported by the subsequent examination of further samples of spotted Allingtons grown in various English counties. The number of spots appearing on individual fruits may exceed 200, but in most cases the highest counts were on terminals and the lowest on laterals.

The external symptoms of the spotting and subsequent rotting on this variety are similar to those already described for Bitter Rot of apples. Internally the first sign of disease is observed when the spots are 1 mm. in diameter, the first and second layers of fleshy cells immediately below the lenticels being grey in colour, collapsed and dead. As the spots increase in size the decay penetrates deeper into the flesh which becomes brown, tough and shrinks, causing the formation of an air cavity beneath the skin. Lesions over 3 mm. in diameter show similar disorders, but the affected tissues are spongy, moist and light-brown to yellow in colour.

Microscopic examination failed to reveal fungal growth in a large proportion of the smaller lesions, whereas all those over 3 mm. in diameter were permeated with septate mycelium from which *G. album* was isolated frequently in the pure state. As a result a large number of isolations were made from all stages of the spots to investigate whether fungal or other agencies are responsible for the initial stages of the disease and also to identify the fungi present in the larger lesions. For this purpose 1,020 isolations were made under two categories :—

(*a*) from lesions 3 mm. or less in diameter ;
(*b*) from lesions more than 3 mm. in diameter.

Isolations were made by peeling the skin with a sharp scalpel so as to expose the discoloured tissues of each lesion. All the exposed tissues of the smaller spots and fragments from the larger lesions were transferred to plates of malt-extract agar. After 10 days those isolations remaining sterile were counted and sub-cultures made from those showing mycelial growth for the purpose of identification. The results are presented in Table II.

TABLE II.

FUNGI ISOLATED FROM TWO STAGES OF THE LENTICEL SPOT DISEASE OF THE VARIETY ALLINGTON PIPPIN.

Fungus isolated.	Lesions up to 3 mm. diam.		Lesions more than 3 mm. diam.	
	Frequency.	%	Frequency.	%
Sterile	279	37.3	0	0
Gloeosporium album	383	51.2	214	78.7
Rhizopus nigricans	37	4.9	4	1.5
Cylindrocarpon mali	21	2.8	39	14.3
Fusarium sp.	9	1.2	—	—
Alternaria sp.	6	0.8	3	1.0
Penicillium expansum	5	0.7	—	—
Trichothecium roseum	5	0.7	8	3.0
Gloeosporium perennans	3	0.4	4	1.5

Of the isolations made from the smaller lesions 37.3% remained sterile. *G. album* was isolated from 51.2%, while seven other fungal species occurred much less frequently. All the isolations from the larger lessions produced mycelial growths, 78.7% of which yielded pure cultures of *G. album*. *Cylindrocarpon mali* was present in 14.3% of the isolations. These results indicate that a high proportion of the small spots on Allington Pippin are not produced by fungal agencies but probably by functional disorders which cause a breakdown of the lenticel tissues subsequently permitting the germination and entry of fungal spores. According to Kidd and Beaumont (14), 10% of the spores present on the surface of apples are localised in the lenticel depressions,

and in the case of Allington Pippin the predominant spore form appears to be that of *G. album* with seven other species also present to a lesser degree.

5. Discussion.

The pathogenicity experiments described above show that *G. album* is non-parasitic to living apple twigs, results which are in agreement with those of Ogilvie (17). Inoculations made on dead twigs were inconclusive but showed that the fungus is capable of forming mycelial cushions beneath the bark, suggesting a rudimentary type of acervulus. *G. album* from both Bitter Rot and infected twigs when inoculated into apple fruits proved to be an active agent of decay both in the sporing and mycelial condition. Marginal rots resulted when mycelial inoculations were applied to apple Scab lesions, proving that the fungus can also penetrate the skin by this means. No rots were formed, however, when similar Scab lesions were treated with spore suspensions.

Numerical data obtained from the examination of some 34,000 apples grown in six different counties during 1937-39 and cold stored at Long Ashton showed *G. album* to be the most important rot-producing fungus during that period. Only minor losses resulted from its entry through skin injuries and Scab lesions, its main method of attack being through the lenticels. When individual healthy lenticels, or those previously treated with strong ammonia vapour, were inoculated with spore suspensions in the laboratory no infection resulted after periods extending up to 8 weeks, strongly indicating that *G. album* is incapable of making a direct entrance into apple tissues through healthy lenticels, a result which is in agreement with those of Osterwalder (19). Nevertheless under natural storage conditions *G. album* does penetrate the lenticels, hence certain changes to these structures must take place to permit the entrance of the fungus by this route. Various workers (6, 14, 21) have indicated that the lenticel tissues of certain varieties of apple, in particular Allington Pippin, are subject to a functional disorder which leaves them susceptible to fungal invasion. One method by which this lenticel breakdown might occur is through the influence of aromatic esters as demonstrated by Kidd and West (11).

An investigation into the possible origin of lenticel rots was made on fruits of Allington Pippin. Isolations made from all sizes of lesions showed 37.3% of those with diameters up to 3 mm. yielded no fungi, whereas lesions with diameters greater than 3 mm. all gave mycelial growth with *G. album* present to the extent of 78.7%. There seems little doubt, therefore, that in this variety the initial stage of many of the lenticel rots is non-parasitic and that the fungi which eventually cause the true lenticel rots, especially *G. album*, can only penetrate the apple tissues because the lenticels have been affected by a physiological breakdown, the causes of which are as yet unknown.

The possibility of meteorological conditions affecting the incidence of lenticel spotting and subsequent rotting must not be overlooked, however, for it has been observed that the disease is more prevalent after wet growing seasons, *e.g.* 1914 (5) and 1936. In Canada, Clements (7) showed that the total number of lenticels per apple is characteristic of the variety and can be varied by altering the amount of water available to the tree during the early development of the fruits. The lenticels may be open or closed, but many of the former may become closed if subjected to conditions favouring dehydration

of the outer apple tissues. Immature apples respond more completely to such treatments than mature apples. It might be argued, therefore, that given wet conditions in July and (or) August more lenticels may be formed on each apple and, again, many of these would remain open owing to the absence of dry conditions. If such lenticels remained open they would provide unobstructed passages to spores present in the lenticel craters. In 1914 and 1936 the July rainfall (as recorded at Long Ashton) was 5.21 in. and 5.85 in. (rain on every day) respectively. Such climatic factors may therefore play some part in the appearance of the disease in certain seasons.

6. Summary.

Inoculation experiments have proved *Gloeosporium album* Osterwalder, to be non-parasitic to living apple branches, but indicate the possibility of its saprophytic existence on the tissues of dead twigs. In the orchard the fungus was found frequently on small dead twigs and pruning snags.

During 1937-39 more rots were caused by *G. album* than by any other fungus on apples grown in six different counties and cold stored at Long Ashton, its main method of attack under these conditions being through the lenticels. In the laboratory, however, the fungus failed to penetrate lenticels to form Bitter Rot lesions, but when inoculated through skin injuries it proved to be an active cause of decay. Mycelial inoculations produced marginal rots around Scab lesions.

Investigations on the lenticel spotting of Allington Pippin fruits (Allington Spot) showed all lesions over 3 mm. in diameter to be infected by fungi, *G. album* being present in 78.7% of those examined. Of the spots under 3 mm. diameter, 37.3% yielded no fungus, indicating that these small spots arose as a result of non-parasitic local breakdown. It is suggested that, in the Allington Spot disease, *G. album* acts mainly as a secondary invader of lesions initiated by functional degeneration of the lenticel tissues.

The part possibly played by meteorological conditions is also discussed.

REFERENCES.

(1) Anon. (1936). *Landw. Jb. Schweiz, 6,* 569.

(2) Anon. (1934). List of common names of British plant diseases. 2nd edition. *British Mycological Society.*

(3) Anon. (1934). *Min. Agric. & Fish. Bull.* No. 79, 69.

(4) Anon. (1943). *Min. Agric. & Fish. Bull.* No. 126, 61.

(5) Barker, B. T. P. (1914). A spot disease of apples. *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton, Bristol,* 97.

(6) Brooks, C. and Cooley, J. S. (1917). Effect of temperature, aeration, humidity on Jonathan Spot and Scald of Apples in storage. *Journ. Agric. Res. 11.* 287.

(7) Clements, H. F. (1935). Morphology and physiology of the pome lenticels of *Pyrus malus. Bot. Gaz. 97,* 101.

(8) Grove, W. B. (1937). British stem and leaf fungi, *2,* 221.

(9) Horne, A. S. and Horne, E. V. (1920). Mycological studies. 1. On the "spotting" of apples in Great Britain. *Ann. App. Biol, 7,* 183.

(10) Horne, A. S. and Horne, E. V. (1920). On spotting of apples. *Gard. Chron. 68,* 216.

(11) Horne, A. S. (1920). Diagnoses of fungi from "spotted" apples. *Journ. Bot. 58,* 238.

(12) Horne, A. S. Fungal diseases of stored apples. *Rept. of the Imp. Bot. Conference, London,* 363.

13) Kidd, M. N. and Beaumont, A. (1924). Apple rot fungi in storage. *Trans. Brit. Myc. Soc. 10,* 98.

(14) Kidd, M. N. and Beaumont, A. (1925). An experimental study of the fungal invasion of apples in storage with particular reference to invasion through the lenticels. *Ann. App. Biol. 12*, 14.

(15) Kidd, M. N. and West, C. (1938). Spotting and other effects on apples in storage due to volatile products from ripe apples of other varieties stored with them. *Journ. Pom. and Hort. Sci. 16*, 274.

(16) Marchal, El. et Em. (1921). Contribution a l'Etude des Champignons Fructicoles de Belgique. *Bull. Soc. Roy. Bot. Belgique 54*, 109.

(17) Ogilvie, L. (1935). The fungus flora of apple twigs and branches and its relation to apple fruit spots. *Journ. Pom. and Hort. Sci. 13*, 140.

(18) Osterwalder, A. (1907). Zur Gloeosporiumfaüle des Kernobstes. *Centralb. f. Bakt. 18*, 825.

(19) Osterwalder, A. (1941). Lagerschorfähnliche Flecken am Glockenapfel. *Schweiz Z. Obst- u. Weinb. 11*, 252.

(20) Schneider-Orelli, O. (1912). Versuche über die Wachstumsbedingungen und Verbreitung der Fäulnispilze des Lagerobstes. *Centralb. f. Bakt. 32*, 161.

(21) Scott, W. N. and Roberts, J. W. (1913). The Jonathan Spot. *U.S. Dept. Agric., Bur. Plnt. Ind. Circular* 112, 11.

(22) Spinks, G. T. (1916). A spot disease of apples. *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton, Bristol*, 27.

(23) Wilkinson, E. H. (1943). Perennial Canker of apple trees in England. *Gard. Chron. 114*, 159.

DOWNY MILDEW OF LETTUCE.

A PRELIMINARY NOTE ON SOME GREENHOUSE EXPERIMENTS.

By LAWRENCE OGILVIE.

In the Long Ashton Report for 1941 (13) reference was made to the prevalence of Downy Mildew on lettuces grown under glass during the late autumn and early winter. Since the varieties Cheshunt Early Giant and Cheshunt Early Ball, which are especially suitable for forcing under these conditions and which are commonly grown, appear to be very susceptible to Downy Mildew, a series of experiments was planned to give more information on the disease and its control, and the results obtained to date are given very briefly below.

Origin of Outbreaks in Glasshouses. During the last three years Downy Mildew has been found on the leaves of Groundsel (*Senecio vulgaris*) in all parts of the Province, in localities far removed from any lettuce plantings, and at all times of the year. The occurrence of the fungus on this host in England has been recorded by Jagger (5) and by other writers. Jagger also found it on Sow-thistle (*Sonchus*) and on *Cirsium* sp., and the following have been found to be heavily infected in the Long Ashton plantations: *Senecio vulgaris*, *Sonchus oleraceus* and *S. asper*, and *Carduus arvensis* (*Cirsium arvense*).

Jagger found that the strain of the mildew occurring on lettuce in the vicinity of London in 1926 was distinct from that on the Composite weeds and the present writer has now shown, in the autumn of 1943, that the form occurring on these weeds at Long Ashton does not infect Cheshunt Early Ball, and conversely that two forms found in Somerset on the Cheshunt varieties will not infect *Senecio* or *Sonchus*. It is therefore clear that in the present instance, at least, the occurrence of these infected weeds near the lettuce plantings did not constitute a danger. It is possible, however, that wild species of *Lactuca*, of which at least two are found in Somerset, may be infected with the lettuce strains of the fungus and this matter is being looked into.

The origin of the outbreaks on lettuce still remains obscure. It has been noticed that the mildew appears on the cotyledons of single scattered seedlings of groundsel at an early stage in their growth, suggesting that the fungus is seed-borne in this case, but seedling infection has not yet become apparent in the case of groundsel seedlings grown under the strictly controlled conditions described below.

If the fungus is carried over on the seeds of weeds it is probable that such would be the case also in lettuce. Previous writers, indeed, have described the occurrence of lesions on the seed stems. It is proposed to prove or disprove this point by spraying seed heads with spore-suspensions.

It is probable also that the fungus may be carried over in the soil from one crop to another in the form of sporangia or oospores. Abundant oospores

have been found in the blackened parts of groundsel leaves after they had been attacked by mildew, but oospores have not yet been found by the writer in the leaves of lettuce. Lettuce seedlings grown on a four-months-old compost of infected lettuce leaves have as yet shown no infection in the course of the writer's experiments.

Downy Mildew is of course found on outdoor lettuces practically throughout the year, and these may serve as a source of infection for indoor crops, especially since the disease is usually exceptionally prevalent and severe on summer plantings which have survived till the late autumn and is not uncommon on seedlings of hardy winter lettuces.

A possible source of infection in badly managed greenhouses is debris reaching the water tanks. It was found that an infected leaf floating in water continued to produce viable conidia for at least a fortnight.

Experimental Methods. In experiments with lettuce Downy Mildew in the past the writer had found difficulty in securing uniform infection. In an investigation on the biology of the fungus Schultz (14) found that a saturated atmosphere at 15—17°C. (59—63°F.) was necessary for stomatal penetration by the germ tubes. These conditions and control of infection were secured in the greenhouse at Long Ashton by sowing the seed in steam sterilized soil in 6 in. pots and placing these on a layer of peat inside 10 in. pots, the top of the latter being covered by a sheet of glass. About 100 seeds were sown in each 6 in. pot.

Fungus infection was obtained by spraying the seedlings with a suspension of spores in distilled water by means of an atomiser. Most successful results were obtained by using spores from a saturated atmosphere. Leaves or pieces of leaf bearing conidiophores were shaken up in distilled water in a beaker and allowed to stand for ten minutes. The clear suspension was then poured into the atomiser through cheese cloth. The leaves were sprayed with the suspension till they were wet thoroughly. The glass covers of the large flower-pots were removed only momentarily for spraying on the suspension and for watering, which was done in the mornings only when required. By means of these methods it was possible to obtain practically complete infection of Cheshunt Early Ball seedlings. Conidiophores were produced on the leaves in five to eight days.

It may be noted that no infection could be got by spraying, with a spore suspension, seedlings growing on damp blotting paper in Petri-dishes.

Relation to Humidity. Schultz (14) found that a saturated atmosphere was necessary for stomatal penetration by the germ tubes, and Schultz and Röder (15) found that the fungus was unable to fructify until the relative humidity rose to 96%. These findings are confirmed by our own experience that it was usually impossible to obtain wholesale infection by spraying plants with spore-suspensions in the open greenhouse, or even in a large partitioned-off chamber of a small greenhouse. Satisfactory results were obtained, however, by the pot method already described. Epidemics in greenhouse lettuce take place during the foggy weather prevalent in autumn, when the disease spreads rapidly, especially in closely-crowded boxes. At other times of the year diseased plants have been found where the plants have been kept wet by drips from the roof of the greenhouse.

Infection in Relation to Age of Plants. Erwin (3, 4) has emphasised that

seedlings can become infected immediately they appear above ground. In our experiments the surface of the soil in the pots was sprayed with spore suspensions just prior to the seedlings appearing above ground. The resulting seedlings became infected, while seedlings sprayed while the cotyledons were still folded became heavily infected and the plants remained capable of being infected till the leaves were at least 4 cm. long. It is usually difficult to infect mature plants by spraying them with spore suspensions.

Effect of Fungicides. Kendrick (8) found that copper dusts were toxic to conidia of Downy Mildew while sulphur dusts were less so, while various authors (3, 4, 17) recommend spraying the seedlings with Bordeaux Mixture during the first week of growth, and in some cases just before setting out.

In our own experiments fungicides were applied to the seedlings before they were sprayed with spore suspensions. It was apparently difficult to obtain complete control of Downy Mildew by these applications, no doubt owing to lack of complete coverage. 0—2% infection only took place after spraying with half strength Bouisol, and with Shirlan (1—300), and dusting with dusts containing 17.5% copper. 5% infection followed an application of ground sulphur, while the control pots were severely infected (over 90%).

Spraying with half strength Bouisol four days after applying the spore suspension gave no control of the disease.

Rsesistant Varieties. Jagger (5), in 1926, tested 68 varieties against a strain of Downy Mildew found in the variety of London. Of these, two French varieties, " Laitue passion blanche à grosse " and " Laitue de Sainte Ilan," were found to be highly resistant or immune. Five distinct forms of the mildew have been discovered in California (7). Schultz and Röder (15) found two physiological races in Germany and concluded that young plants were uniformly susceptible, whatever their behaviour in the field. Macpherson (9), in 1932, in the course of greenhouse trials of lettuce varieties in Lancashire, found that Loos Tennisball and Rosy Spring remained free from the disease, May Queen was quite resistant, while Early French Frame became heavily infected. Golden Ball and Central Market Forcing were intermediate in susceptibility.

Resistance of lettuce seedlings to Downy Mildew has been tested at Long Ashton. Two strains of the fungus have already been found. The first strain, occurring on forced lettuces at Long Ashton, had the following reactions. Varieties found to be highly susceptible were: Cheshunt Early Ball, Newmarket (Trocadero), Sutton's Imperial (a Passion lettuce, grown out-of-doors in the winter) and May King. The variety Gotte à forcer was found to be very highly resistant. Seed of this variety was available from three sources, one of the strains being a French one thought to be resistant to Downy Mildew by a local grower. This strain became infected to the extent of about 2%. The other two strains of Gotte à forcer remained entirely free. One of them was sprayed three times with a spore suspension without contracting the disease.

Repeated trials were also made with seedlings of the other forcing varieties, Golden Ball, Loos Tennisball, Early French Frame and the so-called Blackpool strain of Early French Frame. While Cheshunt Early Ball became severely infected when sprayed with spore suspensions of Downy Mildew, Golden Ball became infected to the extent of about 5%, while the other varieties remained entirely free from the disease. A strain of the fungus with the same reactions was obtained from a greenhouse at Offenham, Worcs.

The second strain of the fungus was obtained from greenhouses at Huntspill, Somerset, where it was found on the variety Cheshunt Early Giant. In variety trials it was found to infect equally severely seedlings of all the following varieties: Cheshunt Early Ball, Golden Ball, Gotte à forcer, Early French Frame, Early French Frame (Blackpool Strain) and Loos Tennisball. It should be noted that in the course of trials during 1941 in the Long Ashton greenhouses reported in the Annual Report for 1941 (13) the following varieties were grown in both heated and cool houses: Gotte à forcer, Early French Frame, and Cheshunt Early Ball. Mature plants of the three varieties developed Downy Mildew almost to the same extent. In this case the second strain of the fungus, described above, was probably implicated.

Suggestions Regarding Control. The following tentative suggestions are made regarding control. Where Downy Mildew tends to give trouble every year in cold houses or frames devoted to lettuces trial might be made of one of the resistant varieties mentioned above in case the first strain of the fungus is present. N. J. MacPherson, for instance, reports that Loos Tennisball has continued to give excellent results in Lancashire.

If the Cheshunt varieties must be grown, the seedlings should be raised in sterilized soil and sprayed or dusted with a copper fungicide or with Shirlan just after coming above ground and possibly just before transplanting. A little heat should be given if possible. The houses in which the plants are put out should be well watered previous to planting and if possible heated so as to maintain a buoyant atmosphere. If the plants develop Downy Mildew after being put out the lower affected leaves should be removed and the temperature raised to 60-65°F. for at least one night (18). The plants should not be watered again unless the ground becomes so dry that the plants wilt. In frames also the disease can usually be kept well in hand if the lower leaves are removed.

REFERENCES.

(1) Beattie, J. H. Lettuce Growing in Glasshouses. *U.S. Dept. Agr. Farmers' Bulln.* 1418, 1924.

(2) Beattie, W. R. Lettuce Growing. *U.S. Dept. Agr. Farmers' Bulln.* 1609, 1940.

(3) Erwin, A. T. Control of Downy Mildew of Lettuce. *Proc. Am. Soc. Hort. Sci.*, p. 161, 1920.

(4) Erwin, A. T. Controlling Downy Mildew of Lettuce. *Iowa Expt. Stn. Bull.* 196, 1921.

(5) Jagger, I. C. Lettuce Mildew. *Ann. Rept. Cheshunt Expt. Stn.* for 1926, p. 35, 1927.

(6) Jagger, I. C. and Chandler, N. Physiologic Forms of *Bremia Lactucae* on Lettuce *Abst. in Phytopath.* 23, pp. 18-19, 1933.

(7) Jagger, I. C. and Whitaker, I. W. The Inheritance of Immunity from Mildew (*Bremia Lactucae*) in Lettuce. *Phytopath.*, 30, pp. 427-433, 1940.

(8) Kendrick, J. B. Toxicity of some Commercial Dusts to Conidia of *Bremia Lactucae. Phytopath.*, 19, p. 1143, 1929.

(9) MacPherson, N. J. Cultivation of Lettuce under Glass with special Reference to Varieties resistant to Downy Mildew. *Journ. Min. Agr.*, 38, p. 998, 1932.

(10) Melhus, I. E. Bremia on Hothouse Lettuce. *Abst. in Phytopath.*, 11, p. 54, 1921

(11) Milbraith, D. G. Downy Mildew of Lettuce in California. *Journ. Agr. Res.*, 23, pp. 989-994, 1923.

(12) Ogilvie, L. Lettuce Growing in the Bristol Province. *Ann. Rept. Long Ashton Res. Stn.*, 1940, p. 35.

(13) Ogilvie, L. and Croxall, H. E. Observations on Downy Mildew and Grey Mould on Glasshouse Lettuces. *Ann. Rept. Long Ashton Res. Stn.*, 1941, p. 76.

(14) Schultz, H. Zur Biologie der *Bremia Lactucae*, Regel, des Erregers des falschen Mehltaus des Salats. *Phyt. Zeit.*, 10, 5, pp. 490-503, 1937. (R.A.M., 17, p. 289).

(15) Schultz, H. and Röder, K. Die Anfälligkeit verschiedener Varietäten und Sorten von Salat (*Lactuca sativa* L. and *L. scariola* L.) gegen den falschen Mehltau (*Bremia Lactucae* Regel). *Züchter*, 10, 7, pp. 185-194, 1938. (R.A.M., 18, pp. 7, 8).

(16) Smieton, M. J. and Brown, W. Botrytis Disease of Lettuce, its Relation to Damping off and Mildew, and its Control by Pentachloronitrobenzene Dust. *Ann. Appl. Biol.*, 27, 4, pp. 489-501, 1940.

(17) Plant Diseases. Notes contributed by the Biological Branch. *Agr. Gaz. N.S.W.*, 49, pp. 559-563, 1938.

(18) The Cultivation of Cheshunt Early Giant Lettuce in Glasshouses. *Circular No.* 9, *Cheshunt Expt. Stn.*, 1942.

THE CONTROL OF BLIGHT *(PHYTOPHTHORA INFESTANS)* ON OUTDOOR TOMATOES.

By H. E. CROXALL.

Climatic conditions in the South-West are such that Blight is likely to be epidemic on outdoor tomatoes in most seasons and cause considerable losses if not complete failures. Spraying with copper fungicdes to control this disease must be regarded as an essential routine operation on this crop. There are, however, few reliable figures available to show the efficiency or otherwise of the different copper sprays available. An attempt has therefore been made to determine how far the various materials are effective under field conditions.

Preliminary Trial in 1942.

The first trial was carried out in 1942 on a commercial grower's planting of the variety Market King. The following materials were used :—Bordeaux mixture, Burgundy mixture, a proprietary fungicide containing red cuprous oxide and a proprietary fungicide containing copper oxychloride. The Bordeaux mixture was used at a strength of 4 : 4 : 100 and the other spray materials were made up so as to contain the same percentage of copper. In addition the spray containing copper oxychloride was also used at the strength recommended by the manufacturers, in which the copper content was 65% of that of the 4 : 4 : 100 Bordeaux mixture. The experimental area was laid out in randomised blocks with three replicates of each treatment and unsprayed controls. Each small plot was 1/15 acre. Spraying was carried out on three occasions, Aug. 12—13th, Aug. 27—28th, and Sept. 15—16th. A spray outfit as described by Kearns (1) was used and each material was applied at a rate of approximately 600 galls. per acre on each occasion.

No obvious damage was caused by any of the materials used, but a slight hardening of the leaves occurred on a number of the plants sprayed with Bordeaux mixture and was also present to a lesser extent in the plots sprayed with the cuprous oxide mixture. Although Blight caused serious losses on other nurseries in the same district it did not appear on the unsprayed plots until Sept. 29th and was never severe. This may have been due to the absence of potatoes near this nursery and to the fact that the experimental plots were surrounded by a large area of sprayed plants. No Blight lesions were seen on any of the sprayed plots, but the absence of a heavy attack made it impossible to place much value on this observation.

Trial at Long Ashton in 1943.

Materials and Methods.

In 1943 a trial of different design was carried out at the Research Station. The treatments used were Bordeaux mixture, the proprietary mixtures containing cuprous oxide and copper oxychloride, and a spray containing copper sebacate. All sprays were made up to contain the same amount of copper as 4 : 4 : 100 Bordeaux mixture. The plot used was planted with the following

six varieties in successive rows: Stonor's M.P., Potentate, Early Market, Market King, E.S.1 and Carter's Sunrise. This sequence was repeated five times across the experimental area. The four spray treatments and the control treatment were superimposed on this layout to form a Latin square of twenty-five six-row plots, each plot covering one sixty-fourth of an acre. Each treatment was replicated five times, and each replicate included a twenty-plant row of each variety of tomato.

The plots were sprayed twice, on July 29th and Sept. 2nd, except in the case of copper sebacate spray which, owing to a shortage of material, could only be used on the first occasion. The spraying was done with a portable, hand-operated, barrow pump as used for sulphuric acid spraying of onion beds (2). Each spray was applied at a rate of approximately five hundred gallons per acre on each occasion.

Results.

As in the previous year spray damage was negligible, although the hardening of foliage on plots sprayed with Bordeaux mixture and the cuprous oxide spray was again observed. Blight was first seen on the control plots in the last week of August and spread rapidly so that by Oct. 1st, when the final picking was done, all the fruit remaining on the unsprayed plots was infected. Most of the fruit on the plots sprayed once with copper sebacate was also infected, but there was only about 2% infection on the other sprayed plots. On all the plots some fruit was infected with *Didymella Lycopersici*, and this disease was apparently not controlled by any of the treatments used.

The weight of marketable fruit of each variety from each plot was recorded throughout the season. To this was added the weight of sound fruit picked green at the end of the season and ripened off under glass. These total yields were analysed statistically and the results are summarised in Tables I and II.

TABLE I.

Weight in Tons per Acre of Tomatoes Picked from Sprayed and Unsprayed Plots.

Variety.	Bordeaux Mixture.	Copper Oxychloride.	Cuprous Oxide.	Copper Sebacate	Control.	S.E.	Difference required for Significance. 5% pt.	1% pt.
Market King ..	12.9**	12.0**	11.5**	6.6*	4.3	0.65	2.01	2.82
Early Market ..	11.3**	10.0**	10.9**	7.3**	4.1	0.64	1.99	2.79
Potentate ..	11.6**	12.2**	12.0**	7.0	4.8	0.82	2.53	3.55
E.S.1.	9.7**	8.8**	8.8**	6.1	4.3	0.67	2.07	2.91
Sunrise	9.9**	9.3**	7.6*	6.1	4.7	0.69	2.12	2.98
Stonor's M.P. ..	8.6**	8.8**	9.4**	5.4	4.9	0.63	1.94	2.73
Total for all Varieties ..	10.6**	10.1**	9.9**	6.4**	4.4	0.38	1.16	1.63

** Yield significantly higher than control yield at 1% pt.
* „ „ „ „ „ „ „ 5% pt.

TABLE II.

Yield of Marketable Fruit from Sprayed Plots Expressed as a Percentage of Yield of Unsprayed Plots.

Variety.	Bordeaux Mixture.	Copper Oxychloride.	Cuprous Oxide.	Copper Sebacate	Control	S.E.	Difference required for Significance. 5% pt.	1% pt.
Market King ..	298**	277**	266**	152*	100	15.09	46.5	65.2
Early Market ..	276**	244**	268**	177**	100	15.79	48.7	68.2
Potentate ..	242**	255**	251**	146	100	17.22	53.0	74.4
E.S.1.	223**	202**	202**	140	100	15.52	47.6	67.0
Sunrise	212**	200**	163*	131	100	14.76	45.5	63.8
Stonor's M.P. ..	178**	180**	194**	112	100	12.98	40.0	56.1
Total Yield of all Varieties ..	244**	232**	227**	147**	100	8.62	26.6	37.3

** Yield significantly greater than control yield at 1% pt.
* „ „ „ „ „ „ „ 5% pt.

On the total yields the increase in crop due to all spray treatments was highly significant. The yields from plots sprayed only once with copper sebacate were significantly lower at the 1% pt. than the yields from the plots sprayed with the other three copper fungicides. There was no significant difference between the yields from the plots sprayed with Bordeaux mixture, copper oxychloride and cuprous oxide. There were some differences in the effects of the treatments on the yields of different varieries, but Bordeaux mixture, copper oxychloride and cuprous oxide produced a significant increase in yield with every variety. Except in the case of the cuprous oxide spray on the variety Sunrise the increases in yield were significant at the 1% pt., and in this case the difference was significant at the 5% pt. The increase in yield caused by the copper sebacate spray was significant only with the varieties Early Market and Market King. The difference in reaction of different varieties is most probably due to the time of ripening of the fruit rather than to differences in susceptibility of the varieties to the disease. The varieties Market King and Early Market, which benefited most from spraying, were the slowest to ripen, so that very little fruit had been picked when the Blight attack started. On the other hand much of the fruit of Stonor's M.P. and to a lesser extent Sunrise, had been picked before Blight became epidemic and also there was less weight of fruit on the top, late ripening, trusses than in other varieties.

Although control was not perfect two sprayings with Bordeaux mixture, copper oxychloride and cuprous oxide were adequate from a commercial point of view. They resulted in the production of over twice the weight of marketable fruit picked from the unsprayed plots, although Blight did not appear until nearly the end of August. It must be remembered, however, that the

first spraying was carried out before the attack started, and that the second application was made shortly after the disease appeared and that by this time the plants had been stopped. There was thus a good covering of fungicide on the plants during the critical period. The single spraying with copper sebacate was not nearly so effective, although it did cause an appreciable increase in yield. Almost certainly if this spraying had been carried out immediately before the disease appeared it would have been considerably more beneficial. On the other hand to have delayed spraying until near the end of August would have been very unwise and might be much too late in many seasons to be effective.

Economic Value of Spraying.

The cost of spraying is extremely small in proportion to the value of the crop which may be saved. Spraying is carried out by contract at a cost of £5 per acre for each application. If a grower has his own spraying equipment and the layout of his plot is convenient for spraying (*vide* Kearns (1)) it should be possible to spray at an even lower cost. The grower of 1–2 acres of outdoor tomatoes would be wise to consider the purchase of an outfit such as was used in the 1943 spraying trial. The cost, about £17, is not excessive, as the outfit would be used over a number of seasons and the grower would have the very big advantage of being able to spray at his own convenience.

The least increase in yield from two sprayings in 1943 was nearly 3 tons in the case of the variety Sunrise sprayed with cuprous oxide. At sixpence per pound, which was the average price realised by tomatoes from this plot, this represents an increase in returns of £160 per acre. The value of crop saved by spraying the variety Market King with Bordeaux mixture was £470 per acre. Over all varieties the average increase in yield obtained by spraying twice with Bordeaux mixture, copper oxychloride, or cuprous oxide was $5\frac{1}{2}$ tons per acre, which at sixpence per lb. represents an increase in returns of £310 per acre. The damage caused by Blight in 1943 was by no means exceptional and equally or even more severe attacks may be expected to occur most seasons in the South-West. Thus spraying is an extremely cheap insurance against heavy losses of a valuable crop and should be carried out as a routine operation every year.

Summary.

1. An account is given of experiments on the control of Blight (*Phytophthora infestans*) on outdoor tomatoes by spraying with various copper fungicides.

2. In both 1942 and 1943 no appreciable damage was caused by any of the spray materials used.

3. In 1942 Blight was not severe on the experimental plots, so it was impossible to assess the comparative value of the materials used.

4. In 1943 two sprayings with Bordeaux mixture, cuprous oxide and copper oxychloride gave adequate control of the disease and caused an average increase in weight of marketable fruit of over 100% as compared with unsprayed controls.

5. One spraying with copper sebacate was not so effective but caused a significant increase in yield.

6. The economic value of spraying is discussed.

Acknowledgments.

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The writer is also grateful to Dr. H. G. H. Kearns for advice on and providing the spraying equipment used in both years.

REFERENCES.

(1) Kearns, H. G. H. A Method of Spraying Outdoor Tomatoes, *Ann. Rept. Agric. and Hort. Res. Sta., Long Ashton*, pp. 70–71, 1941.

(2) Kearns, H. G. H. A Small Acid Spray Outfit for Spraying Onion Beds. *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton*, pp. 77–82, 1942.

SHANKING OF ONION AND SHALLOT ASSOCIATED WITH SPECIES OF *PHYTOPHTHORA*.

By C. J. HICKMAN (Research Officer, Agricultural Research Council).

In March, 1943, some specimens of diseased autumn-sown onions from Stinchcombe, Glos., were sent to the writer by Mr. L. Ogilvie, who had observed a similar trouble in April, 1934, amongst salad onions at Offenham, near Evesham.* They proved to be infected by a species of *Phytophthora*. During the same month, and later in the season, further specimens of the same disease were collected in Worcestershire, received from Hampshire, Buckinghamshire, Carmarthen and Kent, and seen in shallots from Somerset. The disease has now been recorded eleven times on onion and once on shallot.

The outward symptoms of the disease (Fig. 1) are yellowing and shrivelling of the leaves and softening of the base of the plant; in older plants, softening of the bulb itself. In addition, the outer scales are sometimes dull and water-soaked. Some or all of the roots are also attacked; they, too, become soft and water-soaked but dry up rapidly on exposure to air. On cutting open an affected bulb longitudinally, the normally swollen bases of the youngest leaves, together with the tissues of the growing point, are seen to be discoloured and often considerably contracted (Fig. 2). Less commonly, these tissues are not contracted but merely soft and water-soaked. There is usually a sharp line of demarcation at the upper limit of infection, the light green, or white, healthy tissue contrasting sharply with the dull, buff-coloured infected zone. The general symptoms, and in particular, the contraction of the internal basal tissues in maturing bulbs, recall those of the Shanking disease of tulip caused by species of *Phytophthora* (Buddin, 1938). The resemblance between the two diseases goes further than the visible symptoms, however, for every affected onion so far examined has proved to be infected by a species of *Phytophthora*.

Shanking has been recorded in autumn- (2 cases) and spring-drilled onions (6 cases) as well as amongst plants raised in boxes (3 cases). The disease was originally noticed in March and April, 1943, in plants from autumn sowings. In one bed, 70 square yards in area, a patch of approximately 1 square yard was affected and in another bed there were approximately 5% diseased plants. The record on shallot was also made in April. In spring-sown crops symptoms appeared from June onwards. Five of the outbreaks caused insignificant losses, diseased plants occurring singly or in small, scattered patches. In one bed, however, there was a severely affected area of about 0.2 acre, in which an average of 21% of the plants were diseased. There was no evidence that the outbreaks of Shanking in these autumn and spring-sown crops were related to previous cropping with onions. Moreover, no relation could be established between infection and soil conditions, for the disease appeared in crops on light, sandy, well-drained soils and on heavy, moisture-holding Lias clay.

* Unpublished data kindly placed at the disposal of the writer.

ONION SHANKING. FIG. 1. Illustrating the collapse of the leaves and the dull, water-soaked appearance of the outer bulb scales.

ONION SHANKING. FIG. 2. Illustrating the contraction and discoloration of the internal bulb tissues.

Illustrations reproduced by permission from "Gardeners' Chronicle," CXIV, 140 (1943).

There were three records of the disease affecting greenhouse raised, transplanted onions and in one of these the evidence clearly suggested that infection originated in the propagating soil which had been used previously for raising tomato plants. Many of the onion seedlings died in the boxes before planting out and Shanking caused heavy losses after transplanting to the open ground (28% in August). Plants from seed of the same varieties drilled alongside, remained healthy. This outbreak occurred on heavy, wet soil and the disease was observed first in the wettest area of the bed.

There appear to be few records of *Phytophthora* species occurring on onion. *P. Allii*, considered by Tucker (1931) to be identical with *P. parasitica*, was recorded by Sawada as the cause of a leaf and flower stalk disease in Formosa, the description being translated by Tanaka (1917), while recently, a *Phytophthora* species has been described from New South Wales (Anon., 1943) causing a seedling leaf blight. The leaves of the affected plants collected by Mr. Ogilvie in 1934 in the Evesham area were yellow and shrivelled and the bases of the plants soft and permeated by a non-septate mycelium, thought to be that of a *Phytophthora*. No isolations were made, however.

In the present investigation isolations were made from diseased material in every case but one. It soon became evident that the eleven cultures thus obtained were not all of one species—another point in common with tulip Shanking, which is caused by two species, *P. cryptogea* and *P. erythroseptica*. Investigation of the morphology of the fungi associated with onion Shanking has not proceeded far enough to identify all the different species but the cultures can be separated into four groups.

The fungi of the first group were isolated from diseased plants occurring in the autumn sown crops, and from shallot. They are characterised by relatively slow growth, with a preference for medium to low temperatures, features also common to an isolate in the writer's possession, from leeks affected by White Tip (*P. Porri*). Group two is represented by a single culture, isolated in June, which resembles *P. Cactorum*. The fungi of groups three and four, all moderately fast-growing organisms, were isolated from June onwards. Those of group three are characterised by ready and abundant development of sexual organs on oat agar, and, in water culture, by the formation of very variably shaped sporangia. The oogonia and oospores are large, on the average 35 and 32 μ in diameter, respectively, and the antheridia amphigynous. Sexual organs have not been observed in the five cultures of the fourth and last group. The development of contiguously arranged hyphal swellings suggested a resemblance to *P. cryptogea*, but the production of successive sporangia by proliferation within old ones, characteristic of *P. cryptogea*, has not been seen in the writer's cultures.

Wound inoculation experiments have established the pathogenicity of the isolations from onion and shallot, and of the culture from leek, towards onion bulbs. In a single experiment in which agar inoculum of these cultures was placed in contact with the bases of onion plants, transplanted from boxes into pots, the symptoms of Shanking were reproduced in approximately 50% of the plants. Successful re-isolation of the fungus was accomplished, however, with only one culture. Further experiments are in progress.

It is probable that infection is soil borne and in the light of the information collected it is obvious that the soil used for raising plants under glass should

be sterilised and other precautions taken to exclude infection, as in tomato propagation. Until the reasons for infection in field drilled crops are known, little can be said, however, regarding the control of Shanking in the open.

The writer wishes to thank Mr. L. Ogilvie, Mr. W. Buddin, Mr. H. H. Glasscock and Dr. D. L. G. Davies for their help in providing specimens of the disease.

REFERENCES.

Anon. (1943). New Plant Diseases. *New South Wales Agr. Gaz.* 54, 158.

Buddin, W. (1938). Root Rot, Shoot Rot and Shanking of Tulip caused by *Phytophthora cryptogea* Pethybr. and Laff. and *P. erythroseptica* Pethybr. *Ann. Appl. Biol.* 25, 705-29.

Tanaka, T. (1917). New Japanese Fungi. Notes and Translations II. *Mycologia* 9, 249-53.

Tucker, C. M. (1931). Taxonomy of the Genus *Phytophthora* de Bary. Missouri Agri. Crop. Sta. Res. Bull. 153.

INFECTION OF PEA SEEDLINGS WITH THE FUSARIUM CAUSING FOOT ROT, AND SOME ENVIRONMENTAL RELATIONS OF THE FUNGUS.

By D. L. G. DAVIES.*

The Fusarium Foot Rot of peas was first observed in England by Ogilvie (3) in 1929 and the pathogen identified as *F. Solani* (Mart.) Sacc. var. *Martii* (Appel & Wollenw.) Wollenw. f.2 Snyder, formerly known as *F. Martii* v. *Pisi* F. R. Jones. The disease is widely distributed in most pea-growing countries throughout the world ; it appears to be common in England, but is especially prevalent in the Evesham area.

On the mature plant the symptoms are (4) " a dying off of the plants at the time of podding. The affected plants show dark brown to purplish streaks on the lower parts of the stem, and particularly near its junction with the roots. The stem is somewhat constricted over the affected area and is easily broken at or below soil level. The disease tends to spread downwards into the roots, which develop the characteristic streaking and may rot off." In 1931, Ogilvie and Mulligan (5) found that the pea strain of the eelworm *Heterodera Schachtii* was also commonly associated with the disease in the Bristol Province, the premature dying off of the plants being more severe when the eelworm was present.

The present paper is concerned especially with experiments on attack by the fungus on seeds and seedlings, since no clear symptoms of attack in the early stages of the life of the plant had been observed in the field.

Temperature Relations of the Fungus.

The temperatures most favourable for growth of the fungus were determined by inoculating the centres of Petri dishes poured with malt extract agar. These, in triplicate series, were placed in temperatures ranging from 0 to 36° C. for seven days. There was no growth at 0°C. and at 32°C., while the optimum for growth lay between 26 and 28°C. These temperatures are slightly lower than those determined by Jones (2) for the same fungus in the United States. Jones found the growth temperature to range from 5°C. to 34°C. with an optimum of 30-31°C.

Soil thermograph readings at a depth of 4 inches at Long Ashton show that in the second half of June the soil temperature maxima may approach 80°F. (26.5°C.).

Infection Experiments.

Ogilvie and Mulligan (4) carried out many infection experiments with pure cultures of the fungus in which typical foot rot symptoms on mature plants were reproduced. The fungus was re-isolated. The present series of

* Part of a Thesis, entitled " Fusarium Diseases of Crops in the Bristol Province," presented to Bristol University in 1939 for the Degree of Ph.D.

experiments was aimed at ascertaining the effect of infection on seeds and seedlings.

Four isolations were used, two obtained in 1932, one in 1933, and one in 1934. These cultures were grown on sterile bran in conical flasks until the bran was thoroughly permeated by the fungus. This inoculum was then mixed with sterilized soil in various proportions by volume. For the controls, sterilized bran was mixed with the soil in comparable amounts. The pea seeds were surface sterilized by soaking in mercuric chloride for 30 minutes and rinsing in sterile water. The experiments were carried out in a heated greenhouse, unless otherwise stated.

Experiment 1. Fourteen 6 inch pots were filled with sterilized soil and inoculum (infected bran) in the proportion 10 to 1. Eight pots had sterilized soil only. There were 15 seeds per pot.

Results. Emergence. Infested pots, 40%.
Control pots, 96%.

The ungerminated seeds were badly rotted. A few had begun to germinate, but radicles, plumules and cotyledons were attacked. The causative fungus was re-isolated.

In most of the seedlings in the infested series the primary and lateral roots were severely rotted. There was marked blackening above and below the cotyledons, while the roots were discoloured dark brown. The cortex of the base of the stem was found to be packed with fungus hyphae.

Experiment 2. In this experiment boxes were used in place of pots. One half of each of six boxes was filled with a compost consisting of inoculum and soil in the proportion of 1 to 15. This inoculum had been prepared seven days previously and allowed to stand in metal trays in the greenhouse. In the other half of each box, the inoculum was placed in one layer beneath seed level and separated from the seeds by a layer of soil $\frac{1}{4}$ inch thick. Three further boxes, two of which had sterile bran added, served as controls. 80 seeds were sown in each box.

Results. Emergence. Infested boxes. Inoculum mixed with soil, 72%.
Inoculum at seed level, 66.6%.
Control boxes, 90%.

Number of plants finally surviving after five weeks.
Infested boxes. Inoculum mixed with soil, 37%.
Inoculum at seed level, 0%.
Control boxes, 90%.

Plants growing on a concentrated layer of inoculum showed a total decay of cotyledons and root systems with an intense blackening of the region between the point of attachment of the cotyledons and soil level.

Plants growing in the soil containing dispersed inoculum showed a more or less uniform decay of the root systems and "foot." The former were not so severely attacked as in the other treatment.

The causative fungus was re-isolated.

Experiment 3. This experiment was similar to the previous one, with the exception that the inoculum was placed in one layer *above* seed level and separated from the seeds by a $\frac{1}{2}$ inch layer of soil.

Results. Emergence. Infested pots, 23.3%.
Control pots, 90%.

Many of the seeds were completely rotted by the fungus penetrating downwards. All the plants were severely rotted in the region of the epicotyl, which corresponded to the position of the layer of inoculum, and in every case infection had spread downwards to the cotyledons and roots.

The causative fungus was re-isolated.

Experiment 4. In this experiment pea seeds were grown in infested soil in boxes with glass sides, the object being to discover what part of the seedling was first attacked.

Results. It was found that the plants became attacked anywhere in the region extending from hypocotyl to soil level. This agrees both with the observations of Walker and Snyder (10), who considered that the point of attachment of the cotyledons was most susceptible, and with those of Jones (2), who considered that the region between cotyledons and soil was most susceptible.

When a larger proportion of inoculum to soil was used both radicles and plumules became attacked immediately.

Experiment 5. In March 1938, the following experiment was conducted out of doors. Two large wooden boxes 3 ft. x 2 ft. x 9 in. were filled with a rich loamy soil. A 4 in. layer of soil was removed from one box and inoculum was placed in a layer $\frac{1}{2}$ in. thick over the entire soil surface. The inoculum was covered by a 1 in. layer of soil and 400 pea seeds were sown on the surface of this layer of soil and then covered. The other box served as a control, sterile bran being substituted for inoculum.

Germination was approximately 70% in each box and the plants showed normal development. Pod weights taken at the end of June showed no appreciable difference, though the peas growing in infested soil showed a marked blackening of the foot region.

All plants were taken up and pea seeds were sown again during the first week of July. The percentage germination in each box was again more or less equal, being 80% in the control box and 78% in the infested box. A few seedlings were taken from each box during the third week of July and it was observed that those seedlings taken from infested soil bore lesions on the foot region accompanied by black streaks and in some cases an entire blackening. The actual roots were not infected. Seedlings from the control box were perfectly free from any attack.

This was the first time that a foot rot of pea seedlings was induced out of doors, and this was probably due to the concentrated layer of inoculum placed near the seeds and the high temperature conditions prevailing. The seedling attack was not severe and no pre-germination rot or pre-emergence rot was caused by the fungus. Experiment 5 was one of many similar experiments conducted out of doors throughout the year but was the only one in which a seedling foot-rot of peas was induced.

Experiments conducted in the greenhouse revealed the fact that the rate and the severity of the attack of *Fus. Solani v. Martii f.*2 upon pea seedlings was directly proportional to the amount of inoculum used. When inoculum and soil in the proportion of 1:5 were used, a pre-germination, pre-emergence and seedling rot was induced, whilst when the proportion was 1:50 the pea

plants showed symptoms of attack when approaching the podding stage. The effect of the amount of inoculum present may explain the prevalence of this disease in the Evesham area where peas are grown frequently on the same ground so that the amount of inoculum may be built up to a dangerous level.

Another factor influencing the rate of infection indoors, was the seasonal cycle. During late autumn and winter, pea seedlings were found to emerge after seven or eight days whilst during spring and summer emergence took place after four days.

It was found that the degree of pre-germination, pre-emergence and seedling attack was very much higher in autumn and winter than in spring and summer, due to the fact that in autumn and winter the pea passes through its seedling stage over a longer period of time.

Effect of pH of Soil on Susceptibility to Foot Rot.

Potting soil was adjusted to ten different pH's ranging from 2.75 to 8.75 by the method employed by Waksman (9), there being four pots to each pH. Infested bran was added to three of the pots in each series and ten surface sterilized pea seeds were sown in each pot.

There were no significant differences in the amounts of emergence in each series. The plants in the control series grew to the greatest height at pH's 6.5 and 7.14, while in the inoculated series growth was more or less equal throughout the range. In the infested series all the roots of the diseased plants appeared to be equally infected, variation in the severity of attack at different pH points being negligible. Burkholder (1), in his work on the Dry Root Rot of dwarf bean caused by a form of the same fungus as the pea Foot Rot, found that the disease was little affected by soil acidity.

Summary.

1. The temperature relations of the pea Foot Rot fungus *Fusarium Solani* var. *Martii* forma 2 were determined. There was no growth at 0°C. and at 32°C., while the optimum for growth lay between 26° and 28°C. At Long Ashton the soil temperature at a depth of four inches may approach 80°F. (26.5°C.) in the hottest part of the day in the end of June.

2. Experiments conducted in a greenhouse throughout the year showed that the fungus can cause a pre-germination, pre-emergence and seedling rot of peas.

3. It was found that the rate and severity of the attack was directly proportional to the amount of inoculum present in the soil.

4. Out-of-doors seedling attack was induced only under conditions of high temperature.

5. The susceptibility of the pea plant to Foot Rot is not affected by soil acidity. The plants themselves appear to make more vigorous growth on an alkaline soil.

REFERENCES.

(1) Burkholder, W. H. Effect of Hydrogen Ion Concentration of the Soil on the Growth of the Bean and its Susceptibility to Dry Root Rot. *Journ. Agr. Res.*, 44, 2, pp. 175-181 1932.

(2) Jones, F. R. Stem and Root Rot of Peas in the U.S. caused by a Species of Fusarium. *Journ. Agr. Res.*, 26, pp. 459-475, 1923.

(3) Ogilvie, L. Observations on the Diseases of Market Garden Crops in the Vale of Evesham. *Ann. Rept. Agr. and Hort. Res. Stn., Long Ashton*, for 1929, p. 153, 1930.

(4) Ogilvie, L. and Mulligan, B. O. Progress Report on Vegetable Diseases. *Ann. Rept. Agr. and Hort. Res. Stn., Long Ashton*, for 1930, p. 135, 1931.

(5) Ditto for 1931, p. 129, 1932.

(6) Ditto for 1932, p. 110, 1933.

(7) Ditto for 1933, p. 115, 1934.

(8) Ogilvie, L., Mulligan, B. O., and Brian, P. W. Ditto, for 1934, p. 187, 1935.

(9) Waksman, S. A. The Influence of Soil Reaction upon the Growth of Actinomycetes causing Potato Scab. *Soil Science*, 14, p. 68, 1922.

(10) Walker, J. C. and Snyder, W. C. Pea Wilt and Foot Rots. *Agr. Expt. Stn., Univ. of Wisconsin, Madison, Wisconsin, Bull.* 424, 1933.

THE SECRETION OF SALICYLALDEHYDE BY THE LARVAE OF THE BRASSY WILLOW BEETLE *(PHYLLODECTA VITELLINAE* L.*)*

By R. L. WAIN.

Introduction.

The Brassy Willow Beetle (*Phyllodecta vitellinae* L.), which is often responsible for serious damage to *Salix alba* var. *vitellinae* and varieties of *Salix purpurea*, has been described fully by Hutchinson and Kearns (1930) and Kearns (1934). The larvae, of which there are three instars, possess a series of nine pairs of dorsal protrusible glands. By the early second instar these are fully developed and are capable of pouring out a copious flow of glandular fluid when the larva is irritated or disturbed. Whether the glands have solely an excretory function or serve to protect the larva from natural enemies is not known, but the fact that the secretion is only discharged when the larva is disturbed and that it is not present in the adult beetle suggests that it has a protective function. This is supported by the strong odour of the secretion.

It is here interesting to note that Hutchinson and Kearns (*loc. cit.*), investigating the effect of pyrethrum emulsion on the larvae, observed that the insects were able to wash off or considerably dilute the emulsion by pouring out the fluid, so reducing the effect of the spray.

There is no information available on the chemical nature of the secretion. Hollande (1909) and Smirnow (1911) have examined the fluid from the adults of the beetle *Aromia moschata*, which feed on similar salicin-containing leaf material. Unfortunately it has not been possible to consult either of these papers, but according to Wigglesworth (1939) it was found that salicylic acid in the form of an ester is eliminated through a pair of glands in the hind coxae. Garb (1915) noted that the larvae of *Melasoma lapponica* fed on willow leaves, secreted white droplets, acid to litmus and having a strong odour resembling that of prussic acid, but no further attempt was made to establish the chemical composition of the fluid.

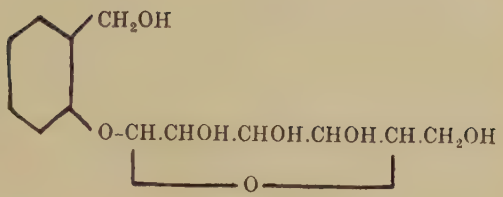
Material.

Some 2,000 larvae were collected in several batches during July 1943 from leaves of *Salix purpurea* growing in the Long Ashton willow beds, and the secretion was obtained from each larva by gently stroking the dorsal region with a small absorbent cotton wool pellet held in forceps. Each pellet was used for 10–12 larvae and in later batches the secretion was taken at two-day intervals, a fresh supply of willow leaves for feeding purposes being provided daily during this period.

For the collection of larvae and glandular fluid the writer is very grateful to Miss S. Sykes, who devoted many hours to the work.

Experimental.

As the willow leaves were known to be rich in the glucoside salicin, the secretion was first examined for the presence of salicyl compounds.



Salicin

The charged pellets were extracted twice in the cold with small quantities of alcohol and the extract filtered. Portions of this solution were then tested as follows :—

(*a*) A drop of aqueous ferric chloride gave an intense violet colouration indicating the presence of a salicyl derivative.

(*b*) Although the extract did not reduce Fehling's solution, it reduced ammoniacal silver nitrate solution.

(*c*) Treatment with a solution of 2:4-dinitrophenylhydrazine in 2 *N* hydrochloric acid produced an immediate turbidity and a crystalline hydrazone quickly separated out. The compound crystallised in dark red needles from alcohol, m.p. 253–254°C indicating salicylaldehyde 2:4-dinitrophenylhydrazone (Curtius and Dedichen, *J. pr.*, 50, 265, give m.p. 248°C).

For comparison, salicylaldehyde was synthesised from phenol by the method of Tiemann and Reimer (*Ber.*, 9, 824) purified through its bisulphite compound and distilled, the fraction b.p. 195–197°C being collected. The compound reduced ammoniacal silver nitrate solution but not Fehling's solution. The 2:4–dinitrophenylhydrazone prepared from the authentic specimen, after recrystallisation from alcohol had m.p. 254–255°C and as the mixed melting point with the hydrazone from the secretion showed no depression, the two compounds were identical. The presence of salicylaldehyde in the secretion was therefore established.

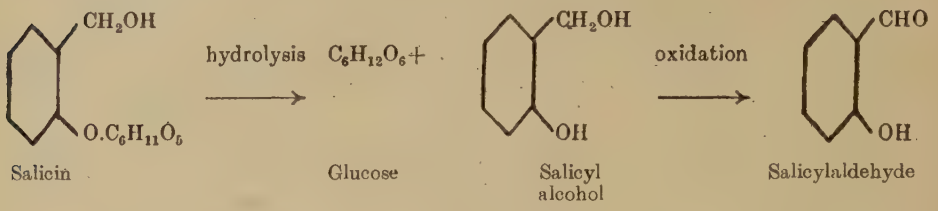
This was confirmed by the preparation of the phenylhydrazone, obtained in small yellow nodules m.p. 139–141°C when crystallised once from methyl alcohol. The phenylhydrazone of the authentic specimen had m.p. 142–143°C (Bamberger *et al*, *Ber.*, 31, 1522, give m.p. 143–144°C) and the mixed melting point again showed no depression.

Discussion.

The above results show that salicylaldehyde is an important constituent of the glandular fluid secreted by the larvae of *Phyllodecta vitellinae* and in view of the presence of salicin in the food material of these insects it is likely that the aldehyde is derived from this source. The statement of Kearns (1931) that there is a correlation between the salicin content of willows and their liability to attack by this insect is of interest in this connection.

The appearance of salicylaldehyde can be explained as follows: After the larva ingests the glucoside, hydrolysis makes glucose available as food material with the simultaneous production of salicyl alcohol. In relation to the insect's metabolism this is a waste product and after oxidation to the

corresponding aldehyde, it is excreted as a strongly smelling constituent of the material exuded from the stink glands.



Salicin — Glucose — Salicyl alcohol — Salicylaldehyde

Summary.

Salicylaldehyde has been shown to be an important constituent of the secretion from the glands of *Phyllodecta vitellinae* L. collected from the leaves of *Salix purpurea*.

REFERENCES.

(1) Garb, G. (1915). "The Eversible Glands of a Chrysomelid Larva, *Melasoma lapponica*." *J. Ent. Zool.*, *7*, 88–97.

(2) Hollande, A. C. (1909). *Ann. Univ. Grenoble*, *21*, 459–517.

(3) Hutchinson, H. P. and Kearns, H. G. H. (1930). "The Control of *Phyllodecta vitellinae* L. (Chrysomelidae)." *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton*, p. 112.

(4) Kearns, H. G. H. (1931). *Ibid.*, p. 199.

(5) Kearns, H. G. H. (1934). "The Control of the Insect Pests of Basket Willows. With special reference to the use of combined insecticidal and fungicidal washes and to methods of application." *Ibid.*, p. 126.

(6) Smirnow, D. A. (1911). *Trav. Soc. Imp. Natur. St. Petersb. Sect. Zool.*, *40*, pt. 4, 15 pp.

(7) Wigglesworth, V. B. (1939). "*The Principles of Insect Physiology*." Methuen, London. p. 332.

THE WIREWORM SURVEY IN THE WESTERN PROVINCE, 1942-3.

By HERBERT W. MILES, D.Sc., Adviser in Entomology.

Survey Technique.

The continuation of the policy of ploughing grass land for arable cultivation during the winter of 1942-43 led to further requests from the technical staffs of county war agricultural executive committees for the estimation of wireworm populations in grass land scheduled for ploughing. Changes in the staff assisting the Adviser in Entomology permitted some reorganization of the wireworm survey work, and from October 1942 a team of two workers was assigned to each of the five counties of the Western Province.* In previous survey work at Long Ashton twenty 4-inch cores of soil were taken from the field, bulked, and brought to the laboratory for examination by the washing method described by Bennett and Kearns (1). In the reorganized survey the soil was examined in the field by hand-sorting, forty $2\frac{1}{2}$-inch cores being examined for each field of about 10 acres; for very small fields the number of cores examined was sometimes reduced, and large fields were subdivided and 40 cores examined in each section. The examination of forty $2\frac{1}{2}$-inch cores gave rather greater accuracy of estimation of wireworm populations than was obtained from the examination of twenty 4-inch cores, but the method of hand-sorting gave less complete extraction of the wireworms from the soil than the washing method previously adopted. The chief advantage of the change in procedure was that surveyed fields were more widely distributed over the province and consequently were more representative of the different conditions of soil, climate and agriculture. The association of a team with a county ensured the interest and co-operation of county technical staffs in the survey. The Adviser in Chemistry co-operated in the wireworm survey by analysing soil from all fields examined for wireworms. This co-operation was invaluable to the Adviser in Entomology, and information on lime status and fertility furnished by the Adviser in Chemistry was of great assistance in assessing the contribution of wireworms to crop failure.

During the winter months the fields examined for wireworms were selected at random by officers of the county war agricultural committees, though it was the usual practice to examine more than one field on a farm in order to reduce the amount of travelling and the consequent loss of time. As spring approached and signs of crop failure became apparent in some fields, the teams were directed to estimate wireworm populations in fields where loss of plants was obvious. Since loss of crop was generally associated with high wireworm populations, the proportion of high populations among sampled fields tended to be greater than in a truly random selection of fields and the proportion of crop failures was similarly affected.

* The following have assisted in the Wireworm Survey:—Miss Britton, Miss Duthoit, Miss Haddock, Miss M. E. F. Jones, Mrs. Miles, Miss Brassington, Miss Harrison, Miss Murphy, Miss B. Smith, Dr. Lloyd, Mr. Mayor, Mr. Stringer.

Fields examined for wireworms were later visited to observe the progress of the crops, and at harvest the yields from sampled fields were classified as satisfactory, S (at least two-thirds of district average) ; poor, P (one- to two-thirds of district average), and failed, F (less than one-third of district average).

Wireworm population in relation to crop establishment.

The extent of wireworm injury to crops is related to the numbers of wireworms present in the soil and reports on the wireworm survey (2) show that the risk of crop failure on newly-ploughed grass land is greatest when the wireworm population is high. Observations on crops in fields where wireworm populations were estimated showed, however, that the health and vigour of the crop at the time of wireworm attack had great influence on the extent and intensity of the signs of wireworm injury. In crops making rapid growth wireworm injury was so masked that the destructive effects of very high wireworm populations were scarcely visible, while in crops where growth was checked by such adverse factors as drought, poor drainage, acidity, temporary or permanent lack of plant food, the loss of plants through attack by even small numbers of wireworms appeared seriously to menace the establishment of the crops.

Cereal crops predominated on fields under observation, and an outstanding character of these crops is their capacity to recuperate after threatened failure. In early spring, mainly during March and April, many cereal crops were thin and unsatisfactory in appearance, had poorly developed roots and were making little growth. In such circumstances the effects of attack by insects were exaggerated and farmers had grave doubts of the ability of their crops to become established. The problem for the farmer was how to encourage growth in the thinned crops so that they had a reasonable chance to overcome the handicap of a bad start. Once good growth was secured, loss from insects and other causes appeared less menacing, the plants gradually filled the rows, and bare patches in the fields became less pronounced. In many cases the crops recovered from the threatened failure and satisfactory yields were obtained.

Distribution of wireworms in grass land 1942-43.

Table I gives a summary of information on the distribution of wireworms obtained from the examination of over 550 grass fields in the Western Province in 1942-43. Wireworm populations were considered high when the estimated population exceeded 600,000/acre, and low when the estimated population was less than 300,000/acre.

While the fields examined were not a random selection of grass fields the table suggests that the level of wireworm population is highest in Herefordshire and lowest in Somerset. Records from Wiltshire were seriously biased by survey work on fields showing signs of crops failure and intensive sampling in a district where the level of wireworm population was known to be high.

Crop results on newly ploughed grass fields.

It was not possible to obtain results from all the newly-ploughed grass fields that had been examined for wireworms, but Table II gives the results obtained for the predominating crops.

TABLE I.

County.	Numbers and percentages of fields grouped according to estimated wireworm population			
	high fields.	medium fields	low fields.	total fields.
Herefordshire	43 63%	13 19%	12 18%	68
Wiltshire	73 42%	39 22%	63 36%	175
Worcestershire	25 32%	28 36%	25 32%	78
Gloucestershire	15 20%	27 35%	34 45%	76
Somerset	12 8%	23 15%	123 78%	158

No conclusions have been drawn from Table II since the fields reported upon were not entirely a random sample. In general, however, results tended to confirm the observation already made (2): that the risks of crop failure were greatest among fields having high wireworm populations. The proportion of poor and failed crops among barley and mixed corn on fields with high wireworm populations exceeded expectation, and it was not possible to determine how far this was the result of biased sampling. The table suggests that spring-sown cereals were rather less successful on newly-ploughed grass land than winter-sown cereals.

A comparison of crop results from the various counties suggested that factors other than wireworm population affected yields. Data on yields of wheat and oats in Herefordshire showed that the proportion of poor and failed crops was approximately 6 per cent., while in Gloucestershire the proportion was 58 per cent., although the level of wireworm population was much lower than in Herefordshire. Soil analyses showed that only some of the grass fields examined were satisfactory as regards lime status and "available" phosphate and potash, and it was observed that signs of wireworm attack were most pronounced when high wireworm populations occurred simultaneously with conditions of low fertility.

Notes on crop results in first, second and third years after breaking.

It has frequently been suggested that second and third crops after the breaking of grass are more susceptible to injury by wireworms than first crops. If this be so then the proportion of unsatisfactory crops should be greater in the second and third years after grass than in the first year. During survey work in the Western Province in 1942-43 estimations of wireworm populations were made on a number of fields carrying second and third crops, and reports on crop performance were obtained from these fields. The numbers of second and third year crops examined were necessarily smaller than those of first year crops and, owing to the normal dispersal of wireworms through cultivation,

TABLE II.

Crop.	Wireworm population.	County.	S.	P.	F.	%S.
Wheat ..	high	Herefordshire ..	16	1	1	
		Wiltshire	13	2	10	
		Worcestershire ..	9	1	3	
		Gloucestershire ..	1	1	1	
		Somerset	0	2	0	
		Total ..	39	7	15	64
	medium	Herefordshire	7	0	0	
		Wiltshire	10	1	0	
		Worcestershire ..	12	2	0	
		Gloucestershire ..	3	10	0	
		Somerset	8	1	3	
		Total ..	40	14	3	70
	low	Herefordshire	4	0	0	
		Wiltshire	19	0	0	
		Worcestershire ..	7	1	0	
		Gloucestershire ..	13	4	2	
		Somerset	51	2	1	
		Total ..	94	7	3	90
Oats	high	Herefordshire	9	0	1	
		Wiltshire	1	2	0	
		Worcestershire ..	0	0	2	
		Gloucestershire ..	0	0	5	
		Somerset	2	1	1	
		Total ..	12	3	9	50
	medium	Herefordshire	3	0	0	
		Worcestershire ..	2	2	0	
		Gloucestershire ..	0	1	1	
		Somerset	3	1	1	
		Total ..	8	4	2	57
	low	Herefordshire	6	0	0	
		Wiltshire	4	0	0	
		Worcestershire ..	1	1	0	
		Gloucestershire ..	3	3	0	
		Somerset	21	1	0	
		Total ..	35	5	0	88
Barley ..	high	All Counties ..	1	3	0	
	medium	,, ..	7	1	0	
	low	,, ..	11	2	0	
Wheat (Spring) ..	high	,, ..	4	2	2	
	medium	,, ..	1	3	1	
	low	,, ..	5	3	0	
Mixed Corn ..	high	,, ..	3	5	0	
	medium	,, ..	1	1	0	
	low	,, ..	4	2	0	
Beans ..	high	,, ..	3	0	0	
	medium	,, ..	1	0	0	
	low	,, ..	1	0	0	
Peas ..	high	,, ..	2	0	1	
	low	,, ..	1	0	0	
Linseed ..	high	,, ..	1	0	0	
	low	,, ..	1	0	0	

few fields had high wireworm populations after the first year of cropping. The following table gives data on crop results at the different levels of wireworm population for the first three years after breaking :—

TABLE III.

Crop	Wireworm population.	Crop results during First year. S	P+F	%S	Second year. S	P+F	%S	Third year. S	P+F	%S
Wheat ..	high	39	22	64	12	4	75	1	0	
	medium	40	16	71	28	2	93	5	1	
	low	94	10	90	55	7	89	33	4	89
Oats ..	high	12	12	50	4	0				
	medium	8	6	57	1	0				
	low	35	5	88	15	2	88	18	1	95
Barley ..	high	1	3		1	0		2	0	
	medium	7	1		3	2		2	0	
	low	11	2	85	8	1		7	2	
Mixed Corn ..	high	3	5		1	1				
	medium	1	1		2	1		2	1	
	low	4	2		11	2	85	1	2	
Total all cereals		255	85	75	141	22	87	71	11	87

From the figures given in Table III it appears that risks of crop failure from wireworm attack are not greater in the second and third years after breaking than in the first year. Crop results were considered in association with soil analyses and the farmers' accounts of the manurial treatment of the fields. The fertility of fields ploughed since 1939, as indicated by soil analysis, was only occasionally satisfactory, and most fields required fertilizer to bring them to an approved standard of fertility. War-time shortages of artificial fertilizers, the general acceptance of the idea of " stored fertility " in grass land, and the tradition that cereal crops need no manurial treatment, have resulted in much land being cropped for three consecutive seasons without any application of fertilizer. Under these circumstances it seems probable that the effects of adverse soil conditions occurring in conjunction with wireworm injury have exaggerated the signs of wireworm attack, and have made it appear that the smaller numbers of wireworms present in the soil in the second and third years after breaking were responsible for greater intensity of wireworm attack.

Wireworm populations of arable land.

Although the war-time extension of arable farming has concentrated attention on the wireworm populations of newly-ploughed grass land, the insects are generally considered to be one of the major pests of agricultural crops and almost every season they are recorded as injurious to crops on established arable fields. In the course of the survey work in the Western Province in 1942-43 wireworm populations of fields under rotation cropping were investigated in order to obtain information on levels of wireworm population in arable land. Table IV shows the numbers of arable fields examined in each county and the average wireworm populations.

TABLE IV.

County.	No. of Fields.	Average population (wireworms/acre).
Herefordshire	50	270,000
Wiltshire	39	48,000
Worcestershire	32	68,000
Gloucestershire	43	43,000
Somerset	24	45,000

Low wireworm populations (under 300,000/acre) were recorded from all the arable fields examined in Wiltshire, Worcestershire, Gloucestershire and Somerset. The average wireworm population for these counties was about 50,000 per acre, and statistical examination of estimated populations (unpublished notes on accuracy of soil sampling for wireworms, D. J. Finney, Rothamsted Experimental Station) indicates that in seven-eighths of all determinations an estimated population of 50,000/acre would indicate a true population not exceeding 120,000 wireworms/acre. In over 100 of the arable fields from these counties the examination of forty $2\frac{1}{2}$-inch cores per field revealed not more than one wireworm, and in only three fields were more than six wireworms found.

The average wireworm population for 50 arable fields in Herefordshire was 270,000/acre. In five fields (10 per cent.) the population exceeded 600,000/acre, and in 10 fields (20 per cent.) the wireworm population was between 300,000 and 600,000 an acre. This high level of wireworm population appears to be associated with local farming practice. Cropping history of the fields examined indicated that during recent years the main crops had been cereals and ley, the ley sometimes remaining 3-5 years. In such circumstances the soil of arable fields remains undisturbed for several seasons and provides conditions somewhat resembling those of grass land. Since leys frequently occurred at intervals of less than four years the wireworms seemed able to persist through the cycle of arable cultivation and provide a substantial nucleus for repopulation.

From the observations on the numbers of wireworms in arable land it was apparent that on land continuously cultivated wireworm populations were low and unlikely to be a menace to most crops. In areas where alternate husbandry was part of local farming practice wireworm populations were likely to be considerable and risks of loss from wireworm attack would be incurred when leys were ploughed.

Crop results from the arable fields under observation were as follows :—

Crop.	S	P	F	%S
Wheat	53	0	0	
Oats	16	4	0	
Barley	10	0	0	
Mixed Corn	6	0	0	
Total ..	85	4	0	95

The proportion of satisfactory cereal crops on arable land was higher than on newly-broken grass land (Table III), probably because the general level of fertility, as indicated by soil analysis, tended to be higher on land regularly under cultivation. Of the four poor oat crops, one was in Herefordshire on a field with a high wireworm population and three were in Gloucestershire on fields where the wireworm populations were low.

Decline in wireworm populations during cultivation.

From data collected during 1942-43 it was possible to compare the levels of wireworm population in land at different stages between grass and established arable land. Table V gives a summary of the collected data.

TABLE V.

County.	Average wireworm populations.			
	First year arable.	Second year arable.	Third year arable.	Established arable.
Herefordshire	764,000 (68 fields)	439,000 (53 fields)	328,000 (53 fields)	270,000 (50 fields)
Wiltshire	512,000 (175 fields)	300,000 (96 fields)	156,000 (71 fields)	48,000 (39 fields)
Worcestershire	498,000 (78 fields)	273,000 (24 fields)	181,000 (9 fields)	68,000 (32 fields)
Gloucestershire	415,000 (76 fields)	170,000 (54 fields)	93,000 (53 fields)	43,000 (43 fields)
Somerset	198,000 (158 fields)	153,000 (37 fields)	134,000 (25 fields)	45,000 (24 fields)

The average wireworm population for the various years of arable cultivation are not strictly comparable since the population estimates were based on the examination of different series of fields during the same year and not on the same series of fields over a period of years, but they serve to indicate the decline in wireworm population that occurs when grass land is brought into cultivation. By the time grass land has carried three arable crops the wireworm population is generally low and approximates that of established arable land.

Summary.

Wireworm survey work in the Western Province in 1942-43 was conducted on a county basis, and population estimates were made on grass land and on new and established arable land. Although the selection of fields for examination was biased by the needs of advisory work it was apparent that the level of wireworm population varied in the different counties. In Herefordshire over 60 per cent. of the grass fields examined had high wireworm populations (over 600,000/acre) and less than 20 per cent. had low populations (under 300,000/acre) ; in Somerset less than 10 per cent. of the fields had high populations and over 70 per cent. low populations, and in Wiltshire, Worcestershire and Gloucestershire the fields were more evenly distributed among the high, medium and low population groups.

Crop failure was most frequent in fields with high wireworm populations, but the proportions given in Table II were biased by the examination of crops where failure was anticipated. A comparison of the numbers of crop failures in the various counties showed that wireworm population was not the only factor affecting yield. A comparison of crop results from new arable fields carrying first, second and third crops respectively indicated that risks of crop failure from wireworm attack were not greater in the second and third year after grass than in the first year.

Observations on wireworm populations in established arable land indicated that in land under frequent cultivation the wireworm population was so low as to be almost negligible. When short periods of cropping with cereals were separated by leys of 2-5 years duration, as in parts of Herefordshire, the level of wireworm population in old arable land was high and constituted a risk to the crops. The decline in wireworm population when grass land was cultivated was demonstrated by a comparison of wireworm populations in land at different stages between grass and established arable.

REFERENCES.

(1) Bennett, S. H. and Kearns, H. G. H. (1943). A Method of Washing Out Wireworms from Soil Samples. *Ann. Rept. Agric. and Hortic. Res. Sta., Long Ashton,* 1942, pp. 49-50.

(2) Anon. (1941). Wireworms and Newly Ploughed Grass Land. *Journ. Min. Agric.,* Vol. XLVII, No. 4, March 1941, pp. 251-257.

FRIT FLY ON OATS IN THE WEST OF ENGLAND.

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In the course of survey work for wireworm injury it was noticed that attack by frit fly was widespread among cereal crops in the Western Province in 1943. Unlike wireworms, which are mainly injurious to the cereal crops on land recently brought into arable cultivation, frit fly attacks cereals on both new and established arable land. Winter wheat and oats are attacked by the autumn generation of the flies; spring cereals, particularly oats, are attacked by the spring generations and finally the grain is attacked by the summer generation. The combined effect of three generations of the insects may result in a serious depression of the yield.

The Frit Fly.

Frit flies are minute shining black flies, about a twelfth of an inch long (Fig. 1) with clear wings extending beyond the tip of the body when the insect is at rest. They are most frequently seen on sunny days at harvest time, when vast numbers are found about the oat sheaves and stooks, and on men, horses and waggons at work in the harvest field.

After harvest the insects scatter and lay their eggs about the shoots of grasses and possibly in the seedlings of early sown winter cereals. The eggs give rise to small yellowish white maggots that bore into the young plants. The feeding of the maggot at the base of the central shoot injures the growing point and attacked plants or shoots turn yellow, shrivel and die. In early attacks the seedlings may not provide sufficient food and the maggots migrate, so that each maggot may destroy several seedlings before it finishes feeding.

In most seasons frit or frit-like maggots are present in winter cereal crops and the injury caused by the maggots is a contributory factor in winter thinning. When injury is distributed throughout the crop and fertility conditions are satisfactory there is some compensatory growth in the remaining plants. When the maggots are numerous, bare patches may occur in the crop as a result of their feeding, but these areas can be patched in the spring. Frit attack on rye-grass generally passes unnoticed since established plants readily produce new shoots to take the places of those destroyed.

During April and May the spring generation of frit flies emerge and lay their eggs on the seedlings of newly sown oats. Some attacked seedlings are killed and the period of attack may continue while the plants are tillering. The maggots feed in the developing tillers and in some seasons over 20 per cent. are infested. A limited thinning of seedlings and tillers may not affect the crop adversely if the seeding rate has been generous and fertility conditions are such that the crop makes rapid growth, but during severe attacks in areas of low fertility bare patches develop in the crop when it is too late for patching with another cereal and the establishment of weeds on the bare patches may affect the condition of the land in the following

season. The loss of tillers in the late spring may be associated with a marked reduction in the yield, since only under conditions of high fertility and rapid growth can late tillers reach maturity in time for harvest.

In the summer another generation of frit flies emerge. These lay their eggs about the young ears, and the maggots feed on the developing grain. It frequently happens that the weight of corn from a field is not as good as was expected, and an examination of the grain before threshing will generally give some clue to the cause. Numbers of grains will be found to be small, mis-shapen, discoloured and crumbly, much below their normal weight or entirely worthless, and in the process of threshing many of them are discarded with the chaff (Figs. 2, 3, 4). In Sweden these imperfect grains were called "frits," and it is now well known that they are caused by the feeding of the frit fly maggots. This attack on the grain has a direct effect on the yield, and when the fritted grains are numerous the weight of crop is seriously reduced. Observations in various parts of the country have indicated that this loss is widespread, and the computations of several authors* suggest that the annual loss is 7—10 per cent. of the grain.

Loss in the Western Province 1943.

A survey of oat crops in the five counties of the Western Province indicated that frit fly injury was prevalent and serious. The direct loss to the grain through attack by frit fly is easily demonstrated and measured, and in order to obtain some estimate of this loss composite random samples of grain were collected from about 200 fields scattered over the province. The crops examined included many of the most popular varieties of oats. Some of the crops were grown on newly broken grassland and others were the normal rotation crops on established arable land. Dates of sowing varied from September to May, but the majority of the crops examined were spring oats. Samples of oat panicles were drawn at harvest time from the stooked sheaves. The grains were removed from the panicles and random samples of about 200 grains were carefully examined for frit injury. Healthy grains were separated from injured grains and both were counted and weighed. The loss in weight was calculated from a comparison of the weight of healthy and injured grains.

In order to have some information concerning the error involved in this method of estimating crop loss 10 separate composite samples were drawn from a single field, and examined separately. In this series of samples the percentage loss of grain was 13.65 ± 4.48, and the percentage loss in weight was 5.47 ±3.08. The field on which the extensive sampling was carried out was not heavily infested by frit fly, and it is probable that the detailed examination of a more heavily infested crop would have shown a smaller standard deviation.

Distribution of the Crops Examined and the Average Loss.

The crops examined were widely distributed throughout the province. Samples were obtained from 41 crops in Herefordshire, 65 in Worcestershire, 22 in Gloucestershire, 48 in Wiltshire and 25 in Somerset. The average loss

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* Fryer & Collin (1924). *Ann. App. Biol.* 11, p. 448.
Miles (1930). *Journ. Roy. Lancs. Agric. Soc.*, p. 7.

FIG. 1.

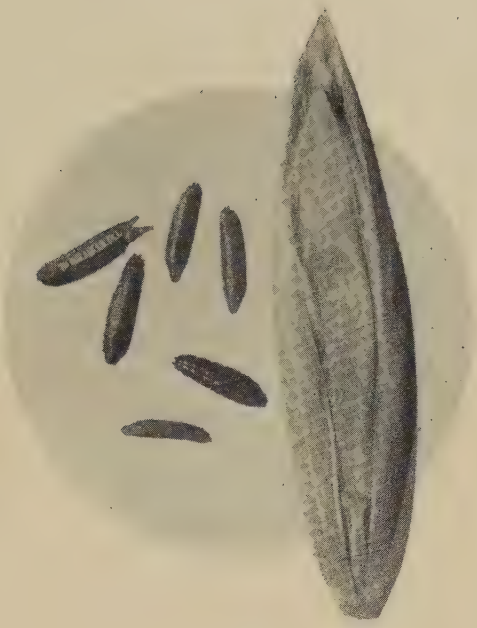

FIG. 2.

FIG. 3.

FIG. 4.

Fig. 1. Frit Flies x 8.
Fig. 2. Oat grain in husk for comparison in size with puparia (chrysalids) of Frit Fly x 8.
Fig. 3. Healthy oat grains x 2.
Fig. 4. Oat grains damaged by Frit Fly x 2.

in weight in 201 fields was estimated at 12.6 per cent., which represents a loss of one sack in eight. The loss in weight was estimated for each county separately. In Herefordshire the loss was 19.4 per cent., in Worcestershire 10.5 per cent., in Gloucestershire 9.3 per cent., in Wiltshire 10.7 per cent. and in Somerset 13.2 per cent. Loss in Herefordshire was well above the average loss for the province and represented a loss of practically one sack in five.

Date of Sowing in Relation to Intensity of Attack.

It has been recognized that the date of sowing affects the intensity of attack by frit fly, and that in order to reduce the likelihood of serious loss to a minimum sowing as early in the season as local conditions permit is constantly recommended. In the crops examined in 1943 the amount of injury to the grain through attack by frit fly was considered in relation to the date of sowing. In the following table the division into early, mid-season, and late crops is arbitrary, and it is recognized that the periods may not be applicable to all districts in all seasons. Crops were classed as early if sown before the last week of March ; mid-season crops included those sown at the end of March and in the first half of April ; and late crops included those sown in the latter part of April and during May.

County.	Early.		Mid-Season.		Late.	
	Av. loss in weight. %	No. of fields examined.	Av. loss in weight. %	No. of fields examined.	Av. loss in weight. %	No. of fields examined.
Herefordshire	15.0	11	19.3	23	27.0	7
Worcestershire ..	7.5	33	17.1	22	14.5	3
Wiltshire	7.6	29	16.4	10	19.2	4
Gloucestershire ..	5.1	8	10.0	7	17.5	4
Somersetshire	9.8	14	8.6	5	23.5	5
Province	8.5	95	16.4	67	21.6	23

From these figures it is apparent that the loss in weight of grain through attack by frit fly is least in crops sown early in the season, and that the risk of loss increases as the date of sowing is postponed.

Effect of Preceding Crop.

It is generally accepted that the intensity of frit fly attack in spring is affected by the nature of the preceding crop. The following table gives an analysis of injury to the grain in relation to the preceding crop.

County.	Loss after Grass. %	No. of fields.	Loss after Cereals. %	No. of fields.	Loss after Roots. %	No. of fields
Worcestershire ..	13.9	10	15.0	15	8.1	30
Herefordshire	15.3	12	20.3	14	24.6	13
Wiltshire	12.1	11	10.1	14	11.9	10
Province	13.8	33	15.1	43	12.8	53

Evidence regarding the effect of the preceding crop is not conclusive. The average loss for 53 fields in which the preceding crop was roots is smaller than that occurring in 76 fields where the preceding crops were cereals or grass, but the difference is not significant.

Susceptibility of Varieties.

The development of oat varieties resistant to attack by frit fly has been under investigation for many years, and in the meantime it has been stated (1) that the variety *Eagle* has shown resistance to injury. Samples from only two crops of *Eagle* have been examined and consequently no conclusions can be drawn from observations concerning them, but though sown in late February, the loss in weight of grain in these samples was not less than the average recorded for the more popular varieties. In the Western Province the most popular varieties of oats in 1943 were *Onward*, *Star*, *Victory*, *Abundance*, *S* 84, and *Black Supreme*. The accompanying table indicates the loss in weight through frit attack on these varieties in the various counties.

Oat Varieties and Attack by Frit Fly in the West of England.

Variety.	Hereford.		Worcester.		Gloucester.	
	Loss in weight. %	No. of fields.	Loss in weight. %	No. of fields.	Loss in weight. %	No. of fields.
Onward	23.4	5	12.5	18	9.0	1
Star	16.3	10	7.4	7	14.0	2
Victory	21.4	8	6.4	8	9.6	11
Abundance	19.0	4	16.4	4	9.0	1
S 84	16.1	7	4.7	1	6.0	1
Black Supreme ..	23.8	6	12.6	10	—	—

Variety—*contd.*	Wiltshire.		Somerset.		Western Province.	
	Loss in weight. %	No. of fields.	Loss in weight. %	No. of fields	Loss in weight. %	No. of fields.
Onward	6.3	3	18.4	5	14.4	32
Star	17.4	10	12.0	11	13.7	40
Victory	8.3	16	5.0	1	10.6	44
Abundance	—	—	5.0	1	15.6	10
S 84	7.5	2	—	—	12.6	11
Black Supreme.. ..	—	—	6.0	1	16.2	17

In view of the small numbers of crops observed in some of the counties only the average loss in weight for each variety over the Western Province as a whole can be considered as representative. Differences in loss between the various varieties are small and not significant. The outstanding feature of the table is that all the popular varieties of oats showed a heavy loss in yield owing to frit fly attack on the grain. Records from 153 fields show an average reduction of 13.4 per cent. of the grain in the six most popular varieties of oats, a loss of practically one sack in seven.

Conclusions and Recommendations.

A survey of 201 oat crops in the Western Province in 1943 showed that loss in yield through frit attack on the grain was considerable. Neither the variety of oat nor the preceding crop appeared to have any consistent effect on infestation of the grain. Sowing oat crops as early as possible in the season seems a reliable way of reducing loss from frit fly to a minimum. It is essential to secure early establishment and tillering of the seedlings, and healthy seed used generously in a firm and fertile soil is an important aid to this end.

The Adviser has been greatly helped in this survey by the co-operation of the field assistants in the counties and by the laboratory staff.

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(1) Armstrong S. F. (1944). *Journ. Min. Agric. Vol. L. No.* 10, *p.* 444.

THE PRODUCTION OF CIDER FRUIT ON BUSH TREES.

VINTAGE QUALITY TRIALS.

PROGRESS REPORT No. 1, 1942 CROP.

By B. T. P. BARKER.

INTRODUCTION.

The first two progress reports on the trials initiated by the Station on this subject were published in its Annual Reports for 1941 and 1942. In the former Swarbrick outlined briefly the objects of the trials in so far as their pomological aspects were concerned and gave details of the soils, lay-out and other particulars for the eight centres at which they have been established : in the latter he dealt with the behaviour of the trees as regards growth and cropping from the time when they were planted in the autumn of 1935, mentioning also that tests on the vintage quality of the respective crops had been started on the 1942 crop by the Cider Section. The present report reviews the results of these initial tests. As a prelude to their consideration it is desirable at this stage to make a more detailed statement than has been given hitherto on the ultimate purpose of this work as a whole.

In the earliest years of the investigations on cider production at Long Ashton it was evident that the outstanding and most difficult problem for solution was the future supply of cider fruit in the necessary quantity and quality for the cider-making industry. The existing orchards at that time were mostly old, past their prime and many in a state of decay : few new ones were being planted to maintain a succession of fruit. The varieties in these orchards were excessive in number and inferior in vintage quality in very many instances. With few exceptions the annual crop tonnage of any individual variety was inadequate to make controlled scientific blending on an extensive scale possible.

The demand for good grade cider on the other hand was steadily increasing. No corresponding increase in the cider fruit crop to become effective quickly could be achieved by new plantings on the orthodox system of standard trees in grass orchards, because along those lines at least a quarter of a century is required to get within range of an annual substantial tonnage of fruit per acre. The latter point also militated against the planting of new cider orchards on account of the long delay in obtaining material returns on the capital outlay.

Thus the question of possible methods to speed up crop production arose. The most obvious course was to grow the trees in the form of bushes instead of standards, associating with that change closer planting and the use of dwarfing stocks to secure heavier crop yields per acre earlier in the life of the plantation. This method had already established itself successfully in general

practice for the commercial culture of dessert and culinary apples. Apart from the features already mentioned it differed from the typical cider orchard method in having the soil tilled and various intercrops grown instead of a permanent grass cover. For application to vintage fruit culture it was necessary to take into account as the first consideration the possible influence of these features on vintage quality, since if that were seriously impaired the method would be useless for its purpose. Further essential points requiring consideration were those concerned with the economics of production, as a comparatively low-priced crop such as cider fruit could not carry the full costs of production associated with the more valuable eating apples. It follows that if the method can produce cider fruit of the necessary vintage quality, some means must be found to reduce costs of production on the cultural side for it to be of practical service to the cider industry.

Preliminary Trials.

As early as 1912 a field trial along these lines was started at Long Ashton with bush trees worked on Rivers' Broadleaved English Paradise stock in the Station's nursery three years previously. There was no room for the trial on the very limited amount of land then in its occupation and a small nearby plot of permanent pasture—the nearest obtainable—was provided by the Ashton Court Estate for the purpose. This was broken up and kept under tillage conditions throughout the duration of the trials. From the beginning very irregular results in tree growth were obtained over the plot and these were clearly not directly due either to the varieties under trial or the kind of rootstock used. Many years later, when Wallace's investigations on the nutrition of fruit trees at the Station had revealed the characteristic symptoms of the respective mineral deficiencies, the primary cause of the irregular growth was shown to be potash deficiency. Other serious disadvantages also were attached to the site and the trial under those conditions did not justify continuance. The trees and crops on the most favourable part of the land had already shown that the method warranted further trial under more favourable conditions.

The necessary area of suitable land at Long Ashton did not become available until 1932. Steps were then taken to raise the required trees in the Station's nursery in numbers sufficient to serve for a comprehensive trial at Long Ashton and supplementary trials at several other centres. These are the trials now being reported upon in the present series of progress reports.

Objects of the Present Trials.

There is no need to recapitulate here the pomological objects of the trials, these having been recorded by Swarbrick in his first two progress reports. Their vintage aspects have not been stated previously. As this is the first occasion on which details of actual vintage quality tests by laboratory analysis of the juices and small-scale cider making tests can be given they need to be prefaced by a statement of the main points at issue.

As far as the writer is aware, apart from the initial bush trial at Long Ashton referred to above, for the first time it will be possible to compare results of vintage quality for individual varieties of cider apples from crops grown on trees identical in make-up, *i.e.* trees of a given scion variety worked on a given variety of rootstock of known behaviour, rootstock influence as

a possible factor in causing variation in vintage results thus being eliminated. Such standardised trees are under trial at the various trial centres ; therefore any differences in the vintage quality of their crops from the individual centres must be attributed primarily to the " locality influence " of the centre. It is recognised that " locality infuence " is a composite factor in itself, individual uncontrollable factors such as soil and climate each playing their part in determining the ultimate result. Similarly, the cultural and management conditions at the individual centres –factors which can be classed as controllable—also come into play in determining the " locality influence." These may include, in addition to tillage operations, such points as pruning, spraying, intercropping of various kinds, partial or complete grassing down, and manurial and other nutritional treatments. At the Long Ashton centre the position is further complicated by deliberate variations in tree form, such as length of leg. There is yet another point relating to " locality influence " which calls for mention here owing to its bearing on vintage quality results ; this is the variation in the time of ripening of the fruit at the individual centres due to that influence. It is known that vintage quality is materially affected by the stage of ripeness of the fruit at the time it is taken from the tree. Hence in these trials allowance must be made for this : instead of harvesting the crops of any given variety of apple on the same date at all the centres the time of harvesting should be varied in such a way as to ensure as far as practicable that all the samples should be at the same stage of ripeness when taken from the trees. It is generally accepted that the proper time to secure maximum vintage quality in the individual apple is when it will fall from the tree on lightly shaking the branches. Thus the standard date for harvesting for any variety at any of the trial centres should be when the crop of the variety in question begins to fall of its own accord in substantial amount. It should be added that the fruit at this stage is not fully mature for milling purposes ; a storage period of a duration depending upon the nature of the variety concerned is still necessary.

The complex nature of " locality influence " has been stressed here partly to show that the vintage quality of samples of any one variety from the trial centres must be expected to show substantial differences from time to time and partly to emphasize the caution necessary in drawing deductions as to the specific cause or causes. Notwithstanding the complexity of the problem it is nevertheless possible by careful analysis of the results over a period of years to gain considerable knowledge and draw sound and valuable conclusions as to fruit quality and the causes of its variations, as has been proved already in the investigations on fruit quality in relation to storage behaviour carried out by Wallace at this Station between 1928 and 1939. The features of those investigations and of the present one on vintage quality dealt with thus far have much in common : the fundamental difference between them is that in the case of the former the ultimate test to which the fruit was subjected was one of storage and in the case of the latter will be conversion into cider. In both cases the required chemical data of the composition of the fruit are of much the same order : but, whereas the results of the fruit storage tests can be assessed with precision, the assessment of the vintage quality in the cider-making tests is more a matter of judgment and liable to be influenced by the sensitiveness of the palates of the tasting panel and personal preference.

METHODS OF TESTING VINTAGE QUALITY.

Arising from this statement is the question as to the adequacy of the present methods of assessing vintage quality. Are they sufficiently delicate for an investigation which is designed in other respects to furnish answers to two of the three pomological features of the trials in which only comparatively small differences in results are likely ? The two in question are the influence of " rootstock " and " length of stem of tree " respectively.

Three kinds of rootstocks are being tested :—(*a*) French seedling crabs, all vigorous enough for use for standard trees, but every individual stock being almost certainly different from the others to at least some small degree, (*b*) Malling No. 1, a vegetatively propagated stock of medium vigour, all individuals of which are true to type, (*c*) Malling No. 9*, a dwarfing stock also vegetatively propagated and true to type (used only at the Long Ashton centre).

Also at the Long Ashton trial centre on each of the two former kinds of stocks duplicate sets of trees are being grown with short stems (2 feet) and long stems (4 feet) respectively.

The third pomological feature of the trials, the " variety " tests, is unlikely to present such difficulty, as the differences between individual varieties are of a larger order, especially in the case of the " sharp " varieties.

At the Long Ashton Centre there is one other feature calling for mention in this connection. The trial plot is situated on a slope and the soil character of the upper part differs appreciably from that of the lower part. The trees are duplicated on each part, both as regards variety, rootstock and length of leg. Thus the sole differences between comparable trees on these plots are those of soil and position on the slope, the other " locality " factors being the same in both cases.

The vintage quality differences in the comparable cases may be slight and difficult to detect or express by the usual methods. It is impossible to say at this stage whether or not more refined methods will be necessary in the three specific cases referred to.

This matter came under consideration when the first vintage quality tests from these trials were made from the 1942 crops. It is now being given closer attention in dealing with the ciders made from the 1943 crops, although final decisions at this stage would be premature since the trees in the trials are still young. The quality of the fruit from young trees is known to be more or less unrepresentative of that of the produce of the more matured tree, and the same has also been proved for the ciders made therefrom.

The methods in use at present fall into two classes :—(*a*) the quantitative analysis of the chemical constituents of the expressed juice of the fruit, (*b*) the conversion of the juice into cider. Uniform methods of cider making are being used in all cases, and the assessment of the quality of each cider compared at various stages of maturity.

As regards (*a*) the following determinations are made :—specific gravity,

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* The trees on this stock were interplanted among the others on the plot as " fillers." Owing to the rapid growth on the plot as a whole the " fillers " must be removed at the end of the 1944 growing season : otherwise the " permanent " trees on the other stocks will suffer. It is proposed, therefore, to start a separate trial plot for trees on No. 9 stock only.

titratable acidity, hydrogen ion concentration, tannin, ash and alkalinity of ash, total combined nitrogen and rate of fermentation. The specific gravity is ascertained by a direct hydrometer reading. The titratable acidity is determined by titration with a standard caustic soda solution, the result being expressed in terms of malic acid. The hydrogen ion content is measured by the standard pH meter made by the Cambridge Scientific Instrument Co. The tannin figure is calculated by the potassium permanganate-indigo carmine method normally used for cider analyses : it is open to the objection that it is not an absolutely accurate figure for a specific tannin, but it gives a fair approximation of the degree of bittersweet character of the juice and, in the present limited state of knowledge of the tannins and related substances of apple juice, is generally accepted as being as serviceable as any for an expression of bittersweet intensity. Ash is determined by calcination of the dried solid matter and its alkalinity is expressed in terms of the number of c.c. of normal caustic soda solution required for its neutralisation. The ordinary Kjeldahl method is used for the determination of total nitrogen : the percentage of nitrogen calculable therefrom thus does not include nitrate nitrogen, if any should chance to be present. The rate of fermentation is obtained by incubating at 25°C. samples of the freshly-pressed juice taken direct from the press, recording the fall in specific gravity every 24 hours until active fermentation ceases, and expressing the rate as the average daily fall in points of gravity over the period of test. As a supplementary check on the rate figure thus obtained, weekly records of gravity fall are taken for the corresponding ciders in bulk in the cider house at ordinary temperature ; these taken in conjunction with the " incubation " results serve to decide into which of the three main classes " quick," " moderate " and " slow " the juice should be ranked.

Two noteworthy omissions in the analytical data will be observed :—(*a*) the content of sugars and (*b*) the total solids. Pressure of other work on the available analytical staff made it necessary to reduce the analyses undertaken to a minimum. It was therefore decided that since approximate figures for these, based on previous records of many hundreds of analyses of cider apple juices, could be calculated from the specific gravity figures, separate estimations should be dispensed with under the prevailing conditions until the further course of the work showed them to be really necessary for the interpretation of the results of the cider-making tests.

The latter constitute the second method utilised for assessing vintage quality. The procedure adopted does not differ in any essential respect from that followed for many years past at the Station in its vintage trials of single varieties of apples, except that centrifuging only has been relied upon to check fermentation at the desired point instead of centrifuging plus filtration or filtration alone. If the difficulties experienced with the ciders of the 1942 crop in respect of secondary bacterial fermentations continue to arise regularly, it may become necessary to include Seitz filtration as well as centrifuging in the normal procedure. It was not included in the first instance, as it was considered that it might tend to interfere with the assessment of that difficult vintage character, body. The ciders in the 1942 trials were centrifuged once only—when the gravity had fallen to 1,025. Since the available quantities of fruit of the individual samples differed considerably and some were only sufficient for laboratory trials, there was an unavoidable

difference in the bulk of liquor at disposal and, correspondingly, in the size and nature of the containers used : but, even although in many cases the juices had to be fermented in glass vessels such as demijohns or gallon jars, modern technique makes it possible to produce samples that are reasonably comparable and the season's trials need not be discounted on that account. Immediately after centrifuging a sufficient quantity of each cider was bottled to serve for sampling requirements later in the year at different stages of maturity. The sampling was done by a small tasting panel in March, June, and September, 1943.

RESULTS.

Many of the varieties included in the trials at individual centres had not come into bearing sufficiently to provide the necessary quantity of fruit for tests purposes : in other cases for various reasons it was not possible to secure fruit from some of the centres. Thus these first tests have been by no means fully representative, but a sufficiently comprehensive collection of samples was obtained to give a fair outline of the kind of differences in behaviour at the respective centres which the tests can reveal and also some guidance as to ways in which the efficiency of the tests can be improved. For the time being transport and other difficulties incidental to war conditions are likely to prevent annual tests from being as representative as could be wished ; but this will give opportunity for the improvement of their technique and the general organisation for their conduct at Long Ashton.

At this stage of the trials it would be premature to discuss in any detailed way the individual results of this first series of tests, but they present some features of definite interest to which attention may be drawn. These are summarised in the following paragraphs.

Juice Composition.

Total Solids and Sugars. As stated above, the specific gravity indicates an approximate value for these constituents : for example, a gravity of 1.050 represents approximately the presence of 10–12 per cent. total sugars and an additional 2–0.5 per cent. non-sugar solids. Taking account of the gravity records variety by variety, the results show that the juices from the Poundisford centre tended to be considerably above the average, and in only one instance (Yarlington Mill) failed to head the list of centres concerned : the Faversham gravities on the other hand were invariably the lowest except in one instance.

Acidity. Both titratable acidity and pH results are considered in this connection. The correlation between them is not very close—even when the statistics relating to the ash are taken into account—and in some cases the variance is exceptionally wide. The most notable examples of this kind were those obtained for the Pertheyre and Broadleaf Norman juices from the Compton Greenfield centre, especially in the former case where the titratable acidities of the two samples were as low as 0.08 and 0.09 per cent. and the corresponding pH 3.37 in each instance. The latter seem abnormally low in view of the unusually low tritratable acidities. It may be significant that in other respects these samples of the two varieties named showed marked

variations from the samples of those varieties from the two other centres submitting them. To some extent the differences may be attributable to the fact that the Compton Greenfield samples of fruit were not milled and pressed until Nov. 13th, the corresponding dates for the other centres being three and two weeks earlier.

One other noteworthy feature under this head is the fact that although the Much Marcle samples of all the varieties submitted contained higher titratable acid than the corresponding samples from other centres, the pH figures for Much Marcle tended also to be higher except in the case of the Dabinett variety, the figures for which suggest that the fruit may have been milled and pressed when less ripe than the samples of that variety from the other centres. This relatively high pH figure was also accompanied by similarly high ash and nitrogen percentages as compared with the other corresponding centres.

Tannins. The only feature of these results was a general tendency for the Poundisford centre samples to give the highest figures for these constituents.

Ash. The total percentage weight of ash present in the respective samples differed very widely, ranging from 0.121 to 0.355. No close correlation has been noted for the same variety at the different centres nor for the individual centres in respect of the varieties grown there, except in the case of the Much Marcle centre already pointed out under "*Acidity.*" Neither does there appear to be any obvious relation between the total ash and the specific gravity : the nearest approach to this was shown by the Faversham samples, which with one exception gave the lowest gravities for each individual variety and, broadly speaking, showed relatively low ash content. It may prove that at this centre potash deficiency may have been responsible for the low figures.

Ash alkalinity, so far as its total is concerned, showed much the same features as the ash percentage, tending to be high in the Much Marcle samples and very definitely low in the Faversham samples, variety for variety.

Total Combined Nitrogen. Here the range of difference was very great, the lowest percentage being 0.002 in the case of Sweet Alford on the crab stock at Poundisford. The highest percentage was 0.041, shown by Pertheyre on the crab stock at Much Marcle. Both these results are records in their respective directions for unfermented apple juices made at Long Ashton. It seems unquestionable that they are valid results, for they are supported by correspondingly low and high results on the other rootstock, M I, for the varieties and centres named.

It is under this head, too, that the most definite and interesting correlations among the whole of the analytical results can be discerned. They relate both to " varietal " and " locality influence " effects.

Dealing with the " varietal " effects first, the individual varieties fall into two well-defined groups (*a*) low to medium nitrogen, (*b*) medium to high nitrogen. The former class includes the varieties Sweet Alford, Ellis Bitter, Yarlington Mill, Kingston Black, Medaille d'Or, Reine des Pommes and Dabinett : the latter, Pertheyre, Broadleaf Norman and Bulmer's Norman.

This classification fits exactly with one made on the basis of average vintage quality from prior knowledge of the varieties concerned gained from actual cider-making trials at Long Ashton over a long period of years. Such a result corroborates the view held since the earliest years of the cider investigations at the Station that high vintage quality is associated with a compatatively low nitrogen content in the juice and *vice-versa*, although until recent years few direct nitrogen determinations have been made and the approximate nitrogen content was deduced from the rate of fermentation data regularly recorded. This is not intended to imply that the nitrogen content is the only factor determining vintage quality : the point is that high vintage quality and a high nitrogen content are rarely associated. The evidence of these trials supports the view that some varieties normally have a lower nitrogen content than others when grown under the same conditions, as in the case of other constituents of the juice, such as malic acid, tannins and sugars. Thus the higher-grade vintage varieties must be sought among those with a natural low nitrogen content. The quantity of nitrogen present is, however, influenced by other factors than the varietal one : a high-grade vintage variety under certain conditions may contain a much higher quantity than its normal and a comparatively low vintage quality juice then result. The converse also applies to low-grade varieties. These points are illustrated in the present tests in the " locality influence " effects mentioned in the second paragraph of this Section.

This " locality influence " shows up very clearly for each of the five centres represented in the 1942 crop tests. The Poundisford Centre is indisputably a " low-nitrogen " one, while Much Marcle is equally obviously a " high-nitrogen" one. Compton Greenfield and Long Ashton are intermediates, and Faversham definitely of the " high-nitrogen " class but not as pronounced as Much Marcle.

Rate of Fermentation. Attention has already been drawn to the complications in the results under this head caused by secondary bacterial fermentations. Without such interference the rates would be expected to run approximately parallel to the nitrogen content on account of the latter's importance for yeast growth. As an example of these discrepancies taken from actual results in the trials, the Sweet Alford juices from Poundisford on the Crab and M I rootstocks respectively showed average gravity falls of 8.2 and 2.3 points at 25° C., although the corresponding nitrogen figures were 0.002 and 0.006 : for the same variety from the Faversham centre there was a fall of 6.6 points with a nitrogen content of 0.020. In the parallel tests carried out in the cider house at ordinary temperature the corresponding rates were 5.5, 1.9 and 8.2 per week. These anomalous results are explainable by the fact that bacterial fermentation was pronounced in the Poundisford juice on the crab stock but not evident in the two other juices : the change in position at 25° C. and ordinary temperature respectively in the Poundisford crab and the Faversham juice is accounted for by the lesser activity of the bacterial fermentation at the lower temperature.

In the cases where bacterial fermentation did not occur—or, if it did, was so slight as to escape notice—the correlation between fermentation rate and nitrogen content of the juices was in general close—although not proportionate—where the differences in nitrogen content were at least moderately

wide. Thus, bearing out this correlation, the respective trial centres group themselves in the manner stated in the last paragraph of the " nitrogen content" section. Small differences in nitrogen content do not provide such close correlation.

It must be taken into account that the "nitrogen content" figure is a comprehensive one and relates not to a single nitrogenous compound but to all the nitrogenous constituents present in the juice. Some of these are of high value for yeast nutrition and thus conducive to high rates of fermentation : others are of less value and some possibly of none, with fermentation correspondingly weak. The fermentation rate in each individual cider is thus largely determined by the relative proportions of these constituents. There appears to be a varietal effect to be considered in this connection. The degree of ripeness of the fruit at the time of expression of the juice is another factor with probable bearing on the comparative results.

Without more specialised data and considerable further investigation apparent discrepancies in correlation between fermentation rates and nitrogen content must remain unexplained. Research in this direction is urgently needed, not merely for the additional knowledge on the primary fermentation but also for its bearing on the relative susceptibility of individual juices and ciders to secondary bacterial disorders, such as those of frequent occurrence during the present series of trials and others, including true " cider sickness," ropiness and oiliness.

Cider Tests.

Detailed notes on characters of the individual ciders have been made and are available for reference at the Research Station. It is proposed to refer here only in summarised form to the varietal features in relation to the trial centres. Evidence as to possible rootstock influence is not sufficiently conclusive to justify detailed consideration here. The bacterial fermentations unfortunately make close comparison impossible in many cases. The comments given on the ciders so affected relate where possible to notes made before the outbreak had become apparent in taste and aroma : in the other affected cases, where the outbreak had become established before the earliest sampling, the comments indicate the nature of the cider after the secondary fermentation had subsided and its outstanding effects on flavour and aroma had disappeared more or less entirely.

Pertheyre. Samples from Poundisford (2), Compton Greenfield (2) and Much Marcle (2). For both the Poundisford and Compton Greenfield Centres the samples could be described as characteristic of the variety, with the former presenting the typical features of a " Somerset " mild-bittersweet type and the latter a lighter, more highly-developed fruity character. The samples from Much Marcle sufficed only for juice analysis requirements.

Broadleaf Norman. Samples from Poundisford (2), Compton Greenfield (2) and Much Marcle (2). The Poundisford samples were of the same general type as those of Pertheyre from the same centre. The Compton Greenfield and Much Marcle ciders were of a lighter character, with the former definitely of a softer type than the latter.

Sweet Alford. Samples from Poundisford (2), Much Marcle (2), Faversham (1) and Long Ashton (1). All samples have the Sweet Alford character. The

Poundisford samples possessed the " Somerset " fullness with the tannin almost up to a mild bittersweet standard, the latter feature applying also to the Much Marcle and Faversham samples. The Much Marcle ciders were brisker than is typical for this variety and the distinguishing feature of the Faversham sample was a pronounced " apple " flavour in its earlier stages of maturity. The Long Ashton samples were typical Sweet Alfords, although some were rather brisker than is usual for the variety : they lacked the body of the Poundisford ciders and the same comment applies to the other two centres.

Ellis Bitter. Samples from Much Marcle (2) and Faversham (1). This Devon variety has a good local reputation in that county as a mild bittersweet, but few cider-making trials have been made with it unblended hitherto. The ciders produced from it in the present trials show it to conform very nearly to its classification : they are border-line examples, coming between the sweet and mild bittersweet classes in flavour. For the two centres submitting samples, Much Marcle and Faversham, the cider from the latter lacked the mild briskness of those from the former—due probably to the more advanced state of ripeness of the fruit at the time of pressing—but the general features were similar in all cases and the fruity character was well-marked. The two Much Marcle samples were closely alike.

Bulmer's Norman. Samples from Much Marcle (2) and Faversham (1). For the two centres concerned the Faversham sample was more fruity and less harsh than the Much Marcle ciders, the mild bitterness shown by the two latter being hardly apparent in the Faversham sample.

Yarlington Mill. Samples from Poundisford (2), Compton Greenfield (2) and Faversham (1). All of a pronounced bittersweet character accompanied by decided harshness of flavour, especially in the Faversham sample. The two Poundisford samples suffered heavily from bacterial fermentation, one of which (Crab stock) after recovery developed into an exceptionally pleasant mild bittersweet type of cider. As a group, a rather harsh type of " Yarlington Mill " cider is a fitting description.

Kingston Black. Samples from Poundisford (2) and Long Ashton (1). The two former were very pleasant ciders of medium acidity for this variety, but with rather pronounced tannin flavour and not very typical Kingston Black character : the Long Ashton sample was less full-bodied with lower acidity and tannin, having some quality but below Kingston Black standard.

Medaille d'Or. Samples from Poundisford (2), Much Marcle (1) and Faversham (1). From the two former centres the ciders were characteristic of the varietal type with tannin less marked than usual and the Much Marcle samples less full-bodied than the others. The Faversham sample was not typical, have developed oiliness and a marked acidity—not present in the fresh juice and associated probably with baterial disorder.

Reine des Pommes. Samples from Poundisford (2), Much Marcle (2) and Faversham (1). All ciders soft and pleasant notwithstanding their high tannin contents. The Poundisford samples were very full-bodied, those from the other two centres being thinner and with somewhat less marked bittersweet character. As a group thay are representative of a pronounced bittersweet variety of high vintage quality.

Dabinett. Samples from Poundisford (2), Much Marcle (2), Compton

Greenfield (2), Faversham (1), and Long Ashton (10). All ciders typically " Dabinett " despite considerable differences in degree of bittersweet character and softness. The Poundisford samples were full-bodied, of low acidity and strong bittersweet flavour; those from Much Marcle less full-bodied and milder bittersweet, but with more acidity than those from any other centre: the Compton Greenfield samples of excellent fruity quality and representative of a high-grade mild bittersweet cider, rather less full-bodied than those from Poundisford; and the Faversham cider a pleasant, mildly acid and slightly harsh medium bittersweet sample of fair body and definite " apple " character. The group of Long Ashton ciders showed considerable variations and most, if not all, were affected by bacterial fermentations; but the sounder specimens were pleasant mild to medium bittersweets of fair body.

SUMMARY AND CONCLUSIONS.

In the present Progress Report a record is given of the first tests on the vintage quality of the crops obtained in the series of trials on the production of cider fruit on bush trees being carried on at Long Ashton and other centres.

Details of the test methods used for assessing vintage quality are stated and the results of the examinations of the available fruit of the 1942 crops from five of the trial centres are summarised and discussed. The detailed analyses and vintage quality notes for the individual ciders have not been published in the text, but they have been prepared in tabular form and are available for reference at the Station.

From the results the following general conclusions apply :—

1. " Locality influence " at the respective centres has produced distinctive effects on vintage quality. In this respect the centres fall into three groups :—

   (*a*) Poundisford, characterised by high specific gravities, slow juice fermentation rates, low acid and nitrogen content, high tannin, and full-bodied ciders.

   (*b*) Much Marcle and Faversham, characterised by quick-fermenting juices of high nitrogen content and relatively low specific gravity.

   (*c*) Long Ashton and Compton Greenfield, intermediate between (*a*) and (*b*) for the characters specified.

2. In general the " locality influence " of the respective centres has been impressed on all varieties tested.

3. Notwithstanding " locality influence " each variety has maintained its " varietal " vintage characters.

4. No clear-cut effects from " rootstock " influence have been apparent.

The results have also demonstrated unmistakably that fruit of good vintage quality can be produced by bush trees grown under the conditions of these trials.

Acknowledgments.

Owing to the resignation of Dr. V. L. S. Charley from the staff of the Research Station the preparation of this Report on the vintage quality tests has fallen to the lot of the writer. Apart from this his only participation in

the work entailed by them has been as a member of the testing panel. He is solely responsible for the discussion on the results and the conclusions thereon. The operations and analytical work involved in the tests were carried out by Dr. Charley and the following members of his staff in the Fruit Products Section :—Miss Kieser, Mrs. Steedman, Miss Tapper and Mr. Burroughs—with the assistance of the cider-house staff in the manual part of the cider-making tests. The organisation of arrangements for the collection of the fruit samples was in the hands of Dr. Swarbrick.

THE TREATMENT OF APPLE POMACE PRIOR TO DRYING FOR SUBSEQUENT PECTIN EXTRACTION.

By L. F. BURROUGHS, MARGARET E. KIESER, A. POLLARD and JOAN STEEDMAN.

Some of the factors involved in the collection and drying of apple pomace for subsequent pectin extraction were discussed in the last Report (1), and attention was drawn to the necessity for the prompt treatment of the fresh pomace to avoid losses in pectin. It was shown that very considerable losses occurred if twice-pressed pomace was stored in the open air for some days before drying.

The pectin extracted from pomace which had been stored in the wet state for varying periods before drying was tested and the jelly forming power was found to fall by 30% after storage for more than one day. Losses occurred in pomace stored either in slab form or after disintegration, and the losses reached 50% after storage for 4 to 6 days. Treatment of the wet pomace with SO_2 to give concentrations of 1000—2500 p.p.m. noticeably retarded the loss in pectin, the losses found being in inverse relation to the amount of SO_2 present. A larger scale experiment in which SO_2 was added to heaps of wet pomace to give a concentration of 1500 p.p.m. showed a good retention of pectin up to the 3-day storage period, although there was a considerable loss of SO_2 from the pomace. It therefore appeared that the addition of SO_2 to wet freshly pressed pomace offered a ready means of preserving the pectin in those cases where it was necessary to hold the pomace for a few days before drying, although evidence was obtained that the actual losses occurring in stored pomace were to some extent dependent on varietal factors and on the condition of the fruit before milling.

In the present series of experiments an attempt has been made to obtain further information regarding—

(i) the actual amounts of SO_2 required to preserve the pectin in fresh pomace ;

(ii) the effect of the degree of maturity of the fruit on the setting power of the extractable pectin, and

(iii) the effect of varying the pH of the solution used for extracting the pectin from pomace derived from fruit at different stages of maturity.

The Effect of SO_2 on the Storage of Wet Pomace.

In the earlier experiments the SO_2 was added to large bulks of pomace which were covered with cloths and stored on a concrete floor in the cider house. As some loss of SO_2 took place during storage, in the present experiments the pomace was stored in closed containers to obtain more constant SO_2 concentrations.

Fresh twice-pressed Kingston Black pomace after disintegration and mixing was filled into 20 (2 lb.) Kilner jars in quantities of 285 g. The pomace was added in three portions, each layer being sprinkled with 5 ml. of SO_2 solution of appropriate concentration to give final amounts in the pomace equivalent to 0, 250, 500, 1000, 1500 p.p.m. Although the SO_2 was added in this manner, complete homogeneity was not attained, for slight banding was visible in the jars of pomace on storage. Several jars of the control sample without SO_2 addition were taken on the same day and the pomace dried in a steam oven overnight to give a control sample before storage, the dry material being finely ground and kept in dry Kilner jars at room temperature. Similar samples were taken from each series over a period of 20 days and the dried material treated in the same manner. Moisture determinations were carried out on each sample of dried pomace and extracts were prepared and tested for setting power by the method described in the previous Report (1), but this year, for the purpose of statistical analysis, six determinations were carried out simultaneously on each sample. It was not possible to test each sample of pomace on the same day that it was dried, but a previous test had shown that a given pomace showed no significant loss in pectin content on storing in the dry condition over a period of 6 days. As fermentation developed in the jars of wet pomace after the first few days, it was necessary to loosen the covers and it was noticed at the time that the series without SO_2 and with the lower SO_2 concentrations (250 and 500 p.p.m.) had developed a strong odour of ethyl acetate. The series with the higher concentrations of SO_2 developed a slight musty smell after 13 days' storage followed later by a distinct smell of butyric acid. Mould growth was apparent in all specimens after 13 days' storage.

The values found for the jelly strengths of the extracts derived from a given weight of dry pomace are given in Table I, each value being the mean of 6 determinations.

TABLE I.

Jelly Strengths of Extracts of Pomace stored with SO_2 before Drying.

	Days of storage of Pomace before drying.	0	1	2	3	4	6	7	13	20
	Initial SO_2 (p.p.m.) SO_2 after 13 days (p.p.m.)									
A.	0 0 ..	4.28	3.96	4.42	3.90	—	2.84	—	3.36	—
B.	250 27 ..	—	—	4.19	4.20	—	—	4.54	3.75	3.86
C.	500 15 ..	—	—	4.03	—	4.62	—	4.69	4.26	3.81
D.	1000 98 ..	—	—	4.27	—	4.47	—	4.18	3.94	3.22
E.	1500 230 ..	—	—	4.60	—	4.29	—	4.44	4.19	2.90

Note.—"Jelly strength" represents the force needed to break a jelly prepared under standardized conditions: for purposes of comparison, a good average pomace has a jelly strength of 3.8—4.0.

The effects of storage up to 13 days and of SO_2 concentration are separated in Table II, in which are shown the means of the values found for each storage period for all SO_2 concentrations, the means for each SO_2 concentration taking all storage periods together and the significant difference (P.=0.05) calculated from an analysis of variance.

TABLE II.

Storage in days.	2	3–4	6–7	13		Significant Difference.
Means	4.299	4.299	4.134	3.902		0.1662
SO_2 in p.p.m. ..	0	250	500	1000	1500	
Means	3.633	4.171	4.397	4.267	4.378	0.1858

Disregarding the effect of SO_2, the loss in setting power of the pomace is seen to be significant only after the 7-day storage period, a definite loss being apparent at the 13-day sampling. The difference between this finding and that of the earlier experiment in which pomace was stored in heaps and which showed large losses in the early stages of storage may no doubt be attributable to the different conditions of storage in the two cases. For in the present experiment, the pomace was undergoing fermentation in a virtually close space and under practically anaerobic conditions ; during the first 7 days mould growth appeared to be inhibited.

The effect of SO_2 is seen in the lower set of figures, where the series without SO_2 shows a significantly lower pectin value than do those containing SO_2 ; all the SO_2 series show an increased retention of pectin, although there is no significant difference between the different SO_2 levels.

The fall in pectin value after 7 days' storage was seen to be coincident with the development of mould growth in the pomace, and it therefore appeared probable that the two factors were related. The relevant data for the effect of storage over this period when mould was present are set out in Table III, in which are given the means of the jelly strengths of extracts of the pomace samples at the four SO_2 levels and over the storage period 7 to 20 days.

TABLE III.

Storage in days.	7	13	20		Significant Difference.
Means	4.295	4.036	3.447		0.2722
SO_2 in p.p.m. ..	250	500	1000	1500	
Means	4.050	4.251	3.782	3.843	0.3142

It will be seen that there is no significant difference between the jelly strengths of extracts made from the pomaces stored for 7 and 13 days, but that there is a definite fall in pectin value at the 20-day storage period. There is, however, no consistent difference to be seen between the different SO_2

levels : the effect of storage from 7 to 20 days being the same for all. Presumably an increase in SO_2 concentration from 250 to 1500 p.p.m. has had no further effect on mould growth or on the other factors operating after the 13-day period.

In conclusion, it may be said that SO_2 at all levels from 250 to 1500 p.p.m. has had a preserving effect on the pectin in the fresh pomace stored in closed containers. A slight loss became apparent after 7 days' storage, but appreciable loss was only seen after 13 days' storage and when mould growth had developed to a considerable extent. The pomace stored without the addition of SO_2 showed a considerable loss of pectin after 3 days' storage.

The Effect of the Maturity of the Fruit on the Pectin of Apple Pomace, and of pH on the Extraction of the Pectin.

To determine whether the optimum degree of maturity of the fruit is the same for pectin extraction as for juice expression, tests have been carried out on pomaces derived from fruit at different stages of maturity. For this purpose a well mixed batch of Dabinett in an immature state was stored in a cool dry position in the cider house and sampled at intervals. Lots of one cwt. were taken at three stages of maturity—

(*a*) when the fruit was firm and immature ;
(*b*) when the fruit was mature three weeks later ;
(*c*) when definitely soft and over-ripe two weeks later, but excluding any rotten or badly damaged fruit.

The apples were milled and twice pressed in a hand press and the disintegrated pomace dried and stored as in the previous tests.

The extraction of pectin from pomace has been found to be most effectively carried out at pH 3, but it was by no means certain that this pH was optimum for pomaces derived from under- or over-ripe fruit. The three pomace samples were therefore extracted at the three pH values 2, 3 and 4, by suitable adjustment of the extracting medium with acid or alkali. The jelly strengths of the resultant extracts are shown in Table IV, each value being as before the mean of six determinations.

TABLE IV.

	Immature.	Mature.	Over-ripe.
pH 2	3.21	3.41	3.52
pH 3	4.66	4.18	3.93
pH 4	4.44	3.90	3.30

In Table V are shown the means of all determinations for the different stages of maturity and for the different pH values.

TABLE V.

Maturity.	Immature.	Mature.	Over-ripe.	Significant Difference.
Means	4.104	3.827	3.581	0.2095
pH	2	3	4	
Means	3.379	4.254	3.879	0.2095

The values for maturity show that the pectin derived from immature fruit gives a higher jelly strength than that from either mature or over-ripe fruit, and the mature fruit gives a higher value than the over-ripe. The jelly strength value is lowest of all following extraction of immature fruit at pH 2, while at all stages of maturity the extraction is most efficient at pH 3.

The results therefore indicate that from the point of view of pectin extraction it is better that the fruit should be slightly immature rather than over-ripe at the time of pressing. But, at the same time, it is clear that the extra pectin obtained from the use of immature fruit would in no way compensate for the correspondingly smaller yield or lower vintage quality of the juice. The utilisation of the fruit in the most satisfactory condition for cider making, *i.e.* in the mature condition, therefore coincides for all practical purposes with the best condition from the point of view of subsequent pectin extraction. Only when the fruit has been allowed to become over-ripe is any serious loss of pectin to be anticipated.

Summary.

1. An examination has been made of the effect of storage on small bulks of wet apple pomace in closed vessels with regard to the setting quality of pectin extracted from the pomace after drying.

2. A loss of setting quality is found after 3 days' storage, but this is less than that taking place in large bulks of pomace exposed to the air.

3. SO_2 in all concentrations from 250—1500 p.p.m. has a preservative effect on the pomace.

4. The loss in setting quality of the pectin in pomace stored with SO_2 is slight up to 7 days but becomes considerable after 13 days' storage, when mould growth has become extensive.

5. The effect of the maturity of the fruit upon the pectin quality of the pomace has been studied and losses in pectin are found to be considerable only when the fruit is allowed to become over-ripe before milling.

6. At all stages of maturity the pectin is most efficiently extracted at pH 3.

Acknowledgment.

We are indebted to Dr. H. Martin for assistance in the statistical analysis of the results, and to Miss R. Tapper for assistance in the analytical work.

REFERENCE.

(1) Charley, V. L. S., Burroughs, L. F., Kieser, M. E., Steedman, J. The Treatment of Apple Pomace prior to Drying for subsequent Pectin Extraction. *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton*, p. 89, 1942.

THE VITAMIN P ACTIVITY OF BLACK CURRANTS.

By A. POLLARD.

INTRODUCTION.

In 1936, Szent-Györgyi and his associates extracted from lemon juice a crystalline flavone fraction to which they gave the name of "Citrin" (1). Guinea-pigs on a scurvy-inducing diet when given daily 1 mg. of Citrin showed a lengthened survival period, suggesting to Szent-Györgyi that scurvy was due not only to the lack of vitamin C but to the absence of a second complementary vitamin. He considered that this vitamin existed in Citrin, and gave it the name of vitamin P by reason of its action on capillary permeability.

The experimental basis for the recognition of the vitamin nature of Citrin remained uncertain for some years, but there now appears to be considerable evidence that the material, or a component of it, has the property of increasing the resistance of the capillary walls, and Scarborough (2) has distinguished two types of haemorrhagic condition, one responding to vitamin C and the other to vitamin P. One of the components of Citrin, a crystalline flavanone glycoside, hesperidin, has been found active in reducing capillary fragility, but its activity is less than that of Citrin itself or of some other preparations from fruits. Methods of biological assay have been worked out by Bacharach and his co-workers (3), who have recently carried out estimations of the vitamin P content of foodstuffs, taking as a provisional standard a calcium derivative of Citrin (Calcitrin).

During the course of some other work in this laboratory, it was observed that there was present in black currants a yellow pigment resembling Citrin in some of its chemical properties, and some study was therefore made of the material in view of the interest already taken in the black currant as a source of vitamin C. A short note upon this has already been published (4), but as it has since been found necessary to bring the experiments to a close, a short description of some later work will be given, although the results obtained are necessarily incomplete.

Experimental.

Biological Activity.

The material originally obtained from black currants had been derived from an amyl alcohol extract of the juice. After the anthocyanin pigment had been removed from the extract, it was found to contain a yellow substance which gave a brown coloration with alkali, a positive cyanidin reaction for flavones and an orange lead salt. Purification through the lead salt gave a yellow gummy material which was tested for biological activity in the Glaxo Laboratories by Mr. A. L. Bacharach, who has kindly carried out assays on the other substances to be described later. It was found that the substance was active in preventing capillary fragility in guinea-pigs maintained on a suitably deficient diet. According to the provisional standard employed by the workers in that laboratory, the black currant material had an activity of

10,600 G.L. Units/g., hesperidin having an activity of 100 G.L. Units/g. and "Calcitrin," the most active preparation from citrus fruits which the Glaxo workers had examined, having an activity of 1,000 G.L. Units/g. A clinical test carried out by Dr. Scarborough in Edinburgh, showed that the material was active on the human subject, but an exact measurement was not possible at the time. In the interval, a number of other preparations of the black currant material have been made as opportunity has arisen, and their activity by guinea-pig test has been shown to be variable, lying mainly between 5,000 and 12,000 G.L. Units/g.

Methods of Isolation.

(i) The original method of isolation employed was based on the extraction of the active fraction from concentrated black currant juice by means of amyl alcohol in the cold. Anthocyanin was removed from the extract by washing with N/50 HCl followed by water and the amyl alcohol was then removed *in vacuo*. The brown syrupy residue was dissolved in a large volume of 95% alcohol and purified by treatment with barium acetate and lead acetate as in the method used by Szent-Györgyi in the preliminary purification of Citrin (5). The resultant lead salt was decomposed with sulphuric acid in alcohol solution to give an amorphous yellow gum soluble in alcohol and in water. The material prepared in this way was found to be physiologically active, as described above.

Attempts to obtain crystalline material from this product were not satisfactory, but it was found that extraction of the material from aqueous solution by means of ether gave two fractions, one more soluble in ether and the other more soluble in water, the ether soluble portion showing a rather higher activity. A simplified method of extraction utilising the solubility of the material in ether was therefore worked out (ii).

(ii) A quantitative extraction of the vitamin P fraction of black currants was attempted using as a starting material the spray-dried juice. This product, which had an activity of 45 G.L. Units/g., was extracted with absolute alcohol for 3 hours in a Soxhlet apparatus under slightly reduced pressure. The extract was concentrated to a syrup *in vacuo* and poured into about 20 times its volume of ether. The precipitated gum, containing the greater part of the alcohol-soluble material and fruit pigment, was re-dissolved in alcohol and again precipitated with ether, the process being repeated four times in all. The ether solutions were combined, washed with N/50 HCl and with water and evaporated to small bulk, giving a crude ether extract. This was found to contain virtually all the activity of the original black currant powder. After purification through the lead salt as before, the final material contained 80% of the original activity and gave an assay of about 12,000 G.L. Units/g. It amounted to 0.04% by weight of the original fresh black currants from which the powder had been prepared. Earlier preparations had been obtained in yields corresponding to 0.015 to 0.03% of the fruit.

This method has been followed in main principle in the preparation of further amounts of the active vitamin P fraction from the spray-dried juice.

Properties.

The physiologically active fraction obtained by the methods described

above shows colour reactions which have been reported for the preparations of other workers, e.g. a yellow colour with alkali which deepens on heating, a positive cyanidin reaction, a green colour with ferric chloride and a yellow colour with boric acid (Wilson, 6). Reactions of this nature are, however, not very specific and are shown by a fairly wide range of compounds of the flavone type. The black currant material also shows a green fluorescence in concentrated sulphuric acid, a reaction not shown by hesperidin or calcitrin and apparently due to the presence of a compound to be described later.

The variable activities of the different preparations and the varying intensities of the colour reactions given suggested that the material was a mixture of flavones and related compounds, possibly present as glycosides. Hydrolysis of the water-soluble and ether-soluble fractions by boiling for several hours with N. H_2SO_4 in water or methanol solution gave in both cases a sugar fraction, a substance very soluble in ether and a dark amorphous product showing an activity equal to about half that of the original material before hydrolysis. The sugar, from the appearance and melting point of the osazone appeared to be glucose ; no evidence for the presence of a methyl pentose could be found. The amount of sugar liberated on hydrolysis suggested that the original fractions were mixtures, for the quantities found, from 6 to 18% of the original materials, were less than would be expected from a glucoside of the type indicated.

Chromatographic adsorption on alumina also gave evidence of non-homogeneity, but the material was adsorbed extremely strongly and was not readily removed from the adsorbent even by the use of mineral acid. It was, however, found possible to obtain an acetyl derivative of the material in reasonable yield and this was adsorbed less strongly on alumina.

Acetylation and Adsorption.

The material was acetylated by heating with sodium acetate and acetic anhydride for a few minutes and then allowing to stand at room temperature overnight. The addition of ice and subsequent extraction with ether gave a syrup from which a small quantity of white crystalline material separated on standing. The latter, after re-crystallisation from ether-alcohol, had a m.p. 195—197°C and did not show the colour reactions described above, which were shown by the non-crystalline fraction. This last fraction when passed in ether solution over a column of alumina (B.D.H.) gave a number of fractions differing in their degree of adsorption which could be removed from the adsorbent by washing with dilute sulphuric acid. From the liberated fractions were obtained further small amounts of crystalline material resembling that described above This material showed no appreciable activity when the small amounts available were assayed. The main fractions were subjected to a further adsorption and acetyl determinations on the final fractions were carried out by hydrolysis in cold acetone solution with sodium hydroxide (Walter, 7).

No marked concentration of vitamin P activity was found in the fractions after hydrolysis, but differences were found in the acetyl values and in the chemical behaviour of the fractions. The acetyl values in terms of N. alkali required for hydrolysis are shown together with the values for some other compounds included for the purpose of comparison. The fraction with the lowest acetyl value showed the strongest adsorption, possibly due to incomplete

Specimen.	ml.N. alkali/g.	Activity in G.L. Units/g.	Adsorption.
WSP4 (5) A1	8.2	2500	weak
WSP4 (5) A2	8.5	3300	strong
WSP4 (5) A3	7.1	2200	v. strong
Crystalline acetyl compound	10.9	—	—
Tri-acetyl hesperitin	7.2	—	—
Tetra-acetyl quercetin	8.5	—	—

acetylation. But this is insufficient to explain some of the chemical differences found, such as a concentration in the weakly adsorbed fraction of the material giving a yellow colour on warming with alkali. It is probable that several closely-related compounds are present in the material, one or more of them having some vitamin P activity. Some of the colour reactions may well be due to some inactive constituent, such as a crystalline compound which has been isolated from black currant pomace and which will be described.

A crystalline compound from blackcurrant pomace.

An extract of 15 k. freshly pressed black currant pomace in 16 l. of 1% HCl was exhaustively extracted with cold ether in a simple form of counter-current extractor and the ether solution concentrated and washed with small amounts of water. On removal of the ether *in vacuo* a greenish-brown residue was given (3.75g.). This had an activity of 1,500 G.L. Units/g. Extraction with petroleum removed some fatty material and the residue was then separated by treatment with glacial acetic acid into a yellow crystalline fraction (WSP4 (7) B) and a syrupy fraction (WSP4 (7) C) which had an activity of about 5,400 G.L. Units /g. and resembled the fractions described earlier.

The yellow crystalline material after recrystallisation from alcohol had an indefinite melting point between 260—270°, but gave a well-characterised acetyl derivative m.p. 192—194°. The compound showed many of the reactions of a flavonol, giving an orange-red lead salt, crystalline salts with strong mineral acids, an intense violet-red cyanidin reaction, a green coloration with ferric chloride and a strong green fluorescence in concentrated sulphuric acid. It dyed wool in the presence of tin, iron, aluminium and chromium with strong shades resembling but not identical with those described for quercetin. It differs from the latter in the colour given with dilute alkali, yielding transient blue and green shades changing to brownish-yellow. The flavonol nature of the material is, however, strongly suggested by its absorption spectrum, which, as shown below, resembles that given by the flavonol glycoside quercetrin. In view of the absence of vitamin P activity, the substance has not been studied further.

Absorption spectra.

The absorption spectra of some of the black currant preparations have been measured by Dr. R. A. Morton in the University of Liverpool, and the values found are tabulated together with the measurements for some other compounds included for comparison. The black currant fractions (designated WSP4) showing vitamin P activity give fairly constant values, with the exception of one of the earlier preparations (WSP4 (01)) which gave an absorption of very low intensity resembling that given by Citrin. The

absorption maxima given by Citrin at 284 and 330 mμ correspond with those found by Morton for a sample of hesperidin obtained from the Glaxo Laboratories, and these differ from those given by the black currant preparations, for the specimen WSP4 (1) with an activity 100 times that of hesperidin, viz. 10,600 G.L. Units/g. shows a high absorption at 297 and 316 mμ.

The crystalline compound WSP4 (7) B, isolated from black currant pomace, is seen to give a high intensity of absorption resembling that given by quercetrin, and cannot be held responsible for the absorption of the active materials. According to Morton, the intensity of absorption suggests that the active black currant preparations do not contain appreciable amounts of non-absorbing constituents and also that the materials do not seem to contain Citrin or hesperidin, particularly since the spectrum is not changed in alkali. As the absorption of Citrin corresponds closely with that given by hesperidin, which is much less active biologically and differs from that given by the black currant preparations, it would appear that the absorption of vitamin P is still undetermined.

MEASUREMENTS OF ABSORPTION SPECTRA.

Substance.	Activity in G.L. Units/g.	In alcohol.		In alkali.	
		max mμ	1% E 1 cm.	max mμ	1% E 1 cm.
WSP4 (01)	not tested	282 330	0.43 0.38		
WSP4 (0)	not tested	293 315		ca 265 330	
WSP4 (1)	10,600	297 316	230 230	298 337	215 215
WSP4 (2) A water sol. fraction ..	1,800	292.5 321.5	98 89		
WSP4 (2) B ether sol. fraction ..	4,900	295 325	256 215		
Calcitrin	1,000			284 342	38 22.5
Hesperidin (Glaxo)	100	285 330	312 62	238 287 358	360 246 110
Hesperidin (Lajos & Gerendás (8))..		278 324	104.7 36.3	287 360	208.9 104.7
Citrin (Lajos & Gerendás)		284 330	120 63	285 360	186 132
Chalcone (Wawra & Webb (9)) ..		308 332			
Eriodictyol (Lajos & Gerendás) ..		290 326	346 245	263 320	408 437
WSP4 (7) B crystalline flavonol (?)	nil	254.5 310 379	505 185 590		
Quercetrin (Lajos & Gerendás) ..		258 375	562 562		

Discussion.

The earlier papers of Szent-Györgyi and his co-workers suggested that Citrin, the fraction of citrus fruits showing vitamin P activity, consisted mainly of hesperidin (the rhamno-glucoside of the flavanone hesperitin) and a glycoside of eriodictyol (de-methylated hesperitin). Purified hesperidin itself was found to possess some activity, but it was much less active than Citrin itself and the other component was therefore considered to be the more active material. The activity of hesperidin might therefore be due to contamination with more active material or activity might be shared by a number of distinct compounds to differing degrees.

Wawra and Webb (9) put forward the statement that the eriodictyol glycoside of Szent-Györgyi was actually the chalcone of hesperidin and that the chalcone, which had biological activity, readily reverted to hesperidin on treatment with acid. The work of Mager (10) has now established, however, that the compound of Szent-Györgyi actually is the rhamno-glucoside of eriodictyol. The relative activities of this and the other components of Citrin are not discussed by this worker. Higby, on the other hand (11), has now stated that the activity of Citrin is to be ascribed to the presence of a water-soluble yellow pigment which he has shown to be the true chalcone of hesperidin. The other compounds isolated from Citrin, viz. hesperidin, limonin and eriodictyol glycoside, did not show the activity. This author suggests that the chalcone of Wawra and Webb was actually impure hesperidin and that its activity was to be ascribed to the presence of a solubilised form of hesperidin in alkaline solution. The absorption spectrum of their preparation does not, however, correspond with that given by hesperidin (q.v.). The chalcone isolated by Higby readily reverts to hesperidin, but he has prepared a methylated derivative which cannot undergo ring closure in this way, and this compound also shows vitamin P activity. The absorption data for the chalcone or for the methyl derivative do not yet appear to be available for purpose of comparison.

It is by no means clear whether this chalcone is the most active form of vitamin yet obtained, and is to be held responsible for vitamin P activity in general. Until a standard biological test and unit of activity are accepted, it is not possible to assess the relative activities of the preparations of different workers. Consequently, vitamin P activity may not be confined to one substance, but may be shown by a number of related compounds to different degrees. The estimation of vitamin P by the use of tests for quercetin-like substances may give misleading results, as is indicated by the isolation of an inactive compound of this type from black currant pomace. At the present time, it is only by the use of a biological assay that the relative activities of concentrates or of foodstuffs can be determined.

Summary.

The isolation has been described of a fraction from black currant juice which shows vitamin P activity to a high degree.

Some of the properties of the material and methods of purification are discussed and an account is given of the absorption spectra of this material and of some other related substances.

A crystalline substance has been isolated from black currants which appears to be a flavonol and does not show vitamin P activity.

A summary is given of some of the recent findings of other workers on this subject, and the nature of the active substances and the methods of estimation are considered.

Acknowledgements.

I am greatly indebted to Mr. A. L. Bacharach for carrying out the biological assays on the vitamin P fractions, and to Dr. R. A. Morton for the spectrographic determinations ; also to Messrs. Kestner Evaporator and Engineering Company for the preparation of the spray-dried black currant juice.

REFERENCES.

(1) Ruszнyák, S., and Szent-Györgyi, A. *Nature*, 138, *27*, 1936.
Armentano, L., Bensáth, A., Béres, T., Ruszнyák, S., and Szent-Györgyi, A. *Ibid* *138*, 798, 1936.
(2) Scarborough, H. *Lancet*, *239*, 644, 1940.
(3) Bacharach, A. L., Coates, M. E., and Middleton, T. R. *Biochem. J.*, *36*, 407, 1942.
Bacharach, A. L., and Coates, M. E. *Analyst*, *67*, 313, 1942, *J. Soc. Chem. Ind.*, *62*, 85, 1943, and in the Press.
(4) Pollard, A. *Nature*, *150*, 490, 1942.
(5) Szent-Györgyi, A. *Z. Physiol. Chem.*, *255*, 126, 1938.
(6) Wilson, C. W. *J. Amer. Chem. Soc.*, *61*, 2303, 1939.
(7) Walter, E. D. *Ibid*, *63*, 3273, 1941.
(8) Lajos, S., and Gerendás, M. *Biochem. Z.*, *291*, 229, 1937.
(9) Wawra, C. Z., and Webb, J. L. *Science*, *96*, 303, 1942.
(10) Mager, A. *Z. Physiol. Chem.*, *274*, 109, 1942.
(11) Higby, R. H. *J. Amer. Pharm. Assoc.*, *32*, 74, 1943.

NOTES ON DOMESTIC FRUIT PRESERVATION.

By ALICE CRANG, D. P. JAMES, M. JONES and M. STURDY.

I. Methods of Bottling Fruit.

Several quick methods of bottling fruit have been tested to see how they compare with the standard methods of sterilizing in water or in an oven.

(*a*) *Boiling Water poured 3 times over the Fruit in the Bottles.*

Gooseberries only have been tested by this method.

The fruit was packed into clean, warmed fruit preserving jars which were then filled with boiling water. This water was poured off, and at once the jars were refilled with boiling water which was also poured off. On filling the third time, the rubber rings and lids were fitted on immediately and the jars left to cool.

The maximum temperatures were recorded in the fruit and the liquid in the centre of 2 lb. preserving jars. These were as follows :—Fruit, 160° F. ; liquid, 179° F. These temperatures should be adequate for sterilizing an acid fruit.

Other jars were stored for 7 months before examination.

Result. The jars were found to be sterile. The fruit was whole, sufficiently cooked and in good condition.

Provided that the fruit is in good condition when used and the jars are closed quickly, this method would seem to be satisfactory for bottling gooseberries. Further tests would be necessary before it could be recommended for any other kinds of fruit.

(*b*) *Sterilizing Bottles of Fruit in Boiling Water.*

This method is sometimes recommended in American books on fruit preserving. The preserving jars were heated, the fruit packed in while they were still warm, and the jars filled with boiling water. The rubber rings and lids were fitted on, the bottles immediately immersed in a pan of boiling water and left in the water for five minutes (the water being heated during this time). The jars were then removed and allowed to cool in the usual way.

Gooseberries were used in this test. Longer times of sterilizing would be necessary for some fruits.

Result. Although the time of sterilizing was shorter than that recommended in this country for canning gooseberries, the jars tested were all sterile after 7 months' storage. The condition of the fruit was quite good, the berries being slightly cracked but not overcooked.

(*c*) *Cold Water Method of Sealing.*

The following method is, from time to time, recommended in the popular press and was tested on this account :—

The gooseberries were packed into clean bottling jars which were filled to

the brim with cold tap water, shaken to release any entrapped air round the fruit, and the jars sealed while under water.

Result. Five out of six jars had severe mould growth after 2 weeks. The other jar was kept for 6 months, and when examined it had badly fermented and the fruit was unfit for use.

(*d*) *Fruit Sterilized under Steam Pressure.*

Steam pressure cookers, as recommended for sterilizing bottled or canned vegetables, were used in the following tests. The fruit was packed into warmed fruit bottling jars, these filled with boiling water, and the rubber rings and lids fixed on securely. The jars were placed on a stand in the pressure cooker which contained boiling water to a depth of $1\frac{1}{2}$ inches. The lid was screwed on tightly. Heat was applied to the cooker (without removing any air pressure in the container) until the pressure on the gauge registered 5 lb. per sq. inch. This pressure was maintained for $3\frac{1}{2}$ minutes to 7 minutes according to the fruit used, then the heat reduced and the jars removed as soon as atmospheric pressure was reached. The lids of the jars were re-tightened if necessary, and the jars cooled in the usual way.

Plums and damsons were treated by this method, sterilizing for $3\frac{1}{2}$ minutes in each case. The total time of heating the fruit in the cooker was $23\frac{1}{2}$ minutes. Whole and skinned tomatoes were also tested, in each case heating the bottles for 7 minutes at 5 lb. pressure, so that the total time of heating the tomatoes was about 27 minutes.

Results. (i) *Plums and damsons.* The fruit at the centre of the bottles reached a maximum temperature of 185° F. The appearance of the bottled fruit was quite satisfactory and little loss of liquid occurred.

(ii) *Tomatoes.* Tests were made on whole unskinned, as well as skinned tomatoes, with hot brine used for filling any spaces. The maximum temperatures of the centre tomato in each pack, when the bottles had been heated for 7 minutes at 5 lb. pressure, were respectively 190° and 198° F.

The appearance of the tomatoes was fairly good, though the unskinned tomatoes were more cracked than would be expected if carefully sterilized at a lower temperature. There was also a slight loss of liquid from the bottles.

(*e*) *Fruit Bottling in a Steam Dairy Sterilizer.*

The experiment was carried out whilst the sterilizer was being used for dairy equipment. A large box type, 5′ x 5′ x 4′, with an $\frac{1}{2}$ inch pipe outlet to the air and clamped door, was used. The boiler generated steam to 30 lb. pressure which was turned into the sterilizing chest. The pressure took between 8 and 12 minutes to drop to zero and the chest was left closed for 20 minutes, as is the normal procedure for dairy equipment.

Tests were carried out using rhubarb, which had been soaked overnight to remove some of the air from its tissues, packed into the " clip top " type of fruit preserving bottle, and the spaces filled with water. Maximum thermometers were inserted in the rhubarb.

Result. After 20 minutes' heating in the sterilizer, the temperature of the rhubarb had reached 200° F. In one jar the increase in temperature had been so sudden that the metal clips, holding the lid in place, had broken and some of the rhubarb and liquid had been forced out of the jar.

The appearance of the jars was very poor, there being considerable loss of the contents and the fruit looking overcooked.

Conclusion.

(*a*) The method of bottling gooseberries, by filling the jars with boiling water three times, seems to be satisfactory provided that the method can be carried out quickly. This method of bottling stone fruits appears to merit further investigation.

(*b*) Sterilizing the warmed bottles, containing unheated fruit and boiling water, in boiling water for a short time also seems worth investigating with different kinds of fruit.

(*c*) The method of storing gooseberries by sealing the bottles under cold tap water, proved, as expected, quite unsatisfactory.

(*d*) If steam pressure cookers are available, they could be used satisfactorily for sterilizing bottled fruit. The fruit was not as broken as might be expected from the quick sterilizing at a comparatively high temperature.

(*e*) The use of a dairy sterilizer cannot be recommended for fruit bottling, as the rise of temperature is too sudden, and the sterilizing time, which would depend on the amount of stoking given to the boiler, is generally too long for fruit, resulting in over-cooking and very poor appearance.

II. Comparison of Covers for Bottled Fruit.

(*a*) *Tests of Various Covers.*

The following comparison was made of various materials and covers available for sealing fruit bottled in jam jars. Six one pound jam jars of raspberries were used in each test, the jars were sterilized in an oven at 240° F. for 1 hour, filled with boiling water and the covers applied at once.

The bottles were stored in the dark at room temperature and examined at intervals for keeping quality.

Method of Sealing.	Results.	
	3 Months' Storage.	8 Months' Storage.
(*a*) 1 thickness of 'Cellophane.'	Mould growth on 4 jars. Severe evaporation.	Remaining 2 jars sound but evaporation of half of the contents.
(*b*) 1 thickness of 'Cellophane' and waxed tissue on the fruit.	Mould growth on 3 jars and some evaporation.	Remaining 3 jars sound. Evaporation of 1/3rd of the contents.
(*c*) 2 layers of 'Cellophane' separated by a thin layer of petroleum jelly.	Mould growth on 3 jars.	Fourth jar showing mould growth. Two satisfactory, showing little evaporation.
(*d*) A layer of paraffin wax on the fruit, covered with 'Cellophane.'	Mould growth on 3 jars. Some evaporation.	3 jars sound; evaporation of about ¼ of the contents.
(*e*) A layer of moisture proof cellulose film.	Mould growth on 4 jars.	2 remaining jars sound; evaporation only slight.
(*f*) Calico, dipped in melted paraffin wax, tied on securely and painted over with more melted wax.	All satisfactory.	All satisfactory.
(*g*) 'Porosan' metal tops and skin rings.	All satisfactory.	All satisfactory.
(*h*) 'Porosan' 2A skin.	All satisfactory.	All satisfactory.
(*i*) Metal tops (ex Messrs. Dewey & Almy Ltd.).	All satisfactory.	All satisfactory.

(b) Use of Sulphur Dioxide in Starch Paste Covers.

Covers made from three different kinds of paper pasted together with starch paste were compared with similar covers in which sulphur dioxide had been added to the paste. The concentration used was 1 " Campden Fruit Preserving Tablet " to ½ pint of starch paste (giving a concentration of about 900 ppm. SO_2).

The jars of fruit were sterilized in an oven at 240° F. for 1 hour, filled with boiling water, and the covers applied at once. The paste was applied to the side of paper nearest to the fruit. Three jam jars of fruit were used in each test.

Cover.	Results after 5 months' storage.	
	Condition Satisfactory.	Mould Growth.
3 layers greaseproof paper with ordinary starch paste ..	—	All jars.
Ditto, with sulphur dioxide added to the paste	All jars.	—
3 layers of parchment with ordinary starch paste.. ..	—	All jars.
Ditto, with sulphur dioxide added to the paste	All jars.	—
3 layers of thick notepaper with ordinary starch paste ..	—	All jars.
Ditto, with sulphur dioxide added to the paste	All jars.	—

Some evaporation of moisture occurred from all the jars.

Conclusion.

The methods of sealing bottles of fruit either with cellulose film alone, or with other substances added to the cellulose to prevent evaporation, were not generally satisfactory.

Calico, treated with melted paraffin wax, as well as three types of covers on sale for sealing fruit bottled in jam jars, gave satisfactory results in these tests.

The addition of sulphur dioxide to starch paste for preparing home-made paper covers for bottled fruit gave encouraging results and seems worth further investigation.

III. Preserving Pulped Fruit with " Campden Tablets."

If fruit, preserved with " Campden Tablets," is required for jam-making, it would require less space if stored in the form of a pulp than as whole fruit in the solution, as at present recommended.

Plums.

The usual method of storing whole plums with the " Campden Tablets " is to use 1 tablet dissolved in 10 fl. oz. water to each 1 lb. of fruit. This amount of solution is required to cover the fruit.

It was found that if the plums were halved and stoned, they could be packed into jars and covered with 3½ fl. oz. of liquid containing 1 " Campden

Tablet ' to each 1 lb. of prepared fruit. Fruit was prepared in this way and stored in preserving jars for 16 months. At the end of that period the fruit was in good condition, the SO_2 content being 238 p.p.m.

In another series, the plums were cooked with just sufficient water to prevent burning and the stoned pulp preserved. " Campden Tablets " were added in the proportions of 1 tablet to each 8 oz., 16 oz., and 20 oz. of the pulp ; in one series the preservative was added while the pulp was hot and in the second, when the pulp was cold. The preserved pulp was immediately sealed. The pulp in all the jars was in satisfactory condition after 16 months of storage in glass fruit preserving jars.

Jam was made from pulp which had been preserved with 1 tablet to each 1 lb. of pulp (containing 261 p.p.m. of SO_2). After a total of 7 minutes' cooking with sugar to reach the setting point, the jam contained only 9 p.p.m. SO_2.

Apples.

A similar comparison was made in storing apples with " Campden Tablets." The method usually recommended is to store peeled, sliced apples (cooking varieties) with solution made from 1 tablet to each $\frac{1}{2}$ pint of water, this being sufficient for 1 lb. of fruit.

The alternative methods tested were to blanch the slices for about 3 minutes in boiling water, so that they would pack more closely, and also to pulp apples, adding enough water to prevent burning and then boiling until most of the extra water had been removed.

The blanched slices were packed into jars, and 1 " Campden Tablet," dissolved in a teaspoonful of warm water, added to each 1 lb. of fruit. "Campden Tablets " were added to the apple pulp in the proportions of 1 tablet to 1 lb., 20 oz., and 26 oz. of the pulp. All the bottles of apples were satisfactory after 14 months' storage.

Conclusion.

If fruit preserved with " Campden Tablets " is needed for use later in jam, considerable saving of storage space will be effected if plums are halved and stoned or else pulped before preserving. Similar saving of space can be made by blanching apple slices or else pulping these before storing. All the jars of fruit kept satisfactorily with the concentrations of sulphur dioxide used when stored in glass preserving jars, but further tests are required to see if these quantities would be sufficient in other jars stored with " home-made " covers. Jam can be made quickly from the pulp without there being an excessive amount of sulphur dioxide retained.

Summary.

I. Three quick methods of bottling fruit which seem worth further investigation are :—

(1) Pouring boiling water over the fruit in the bottles three times.
(2) Sterilizing the bottles of fruit in boiling water.
(3) Sterilizing the bottles of fruit under steam pressure.

The method of sterilizing bottles of fruit with dairy equipment was not satisfactory, nor was the method of storing gooseberries in cold water.

II. The use of various cellulose films for covering bottled fruit was not satisfactory. Calico, treated with melted paraffin wax, gave better results.

The addition of sulphur dioxide to starch paste used in preparing paper covers gave encouraging results.

III. Considerable saving in storage space can be effected if plums, preserved with " Campden Tablets " for use later in making jam, are halved and stoned or else pulped before preserving. Jam can be made quickly from this pulp without there being an extensive amount of sulphur dioxide retained.

A NOTE ON THE TOUGHENING OF GOOSEBERRIES PRESERVED WITH SULPHUR DIOXIDE.

By ALICE CRANG and DILYS P. JAMES.

In the 1941 Annual Report of the Long Ashton Research Station (pp. 118 to 124) an account was given of the method of preserving fruit with the Campden Fruit Preserving Tablets, in which it was noted that the preservative had a toughening effect on the skins of gooseberries.

The preserving agent in this method is sulphur dioxide. In peace-time this was supplied from this Department as " Campden Preserving Solution." In 1940 it was superseded by the " Campden Preserving Tablet," which contained a known weight of potassium metabisulphite as the source of sulphur dioxide. Owing to the shortage of potash in the country, the sodium salt was later used, and the " Campden Tablet " now retailed by the trade contains sodium metabisulphite.

It was thought that the toughening of gooseberries preserved by this method might be due to the hardness of the water used in making the preserving solution. Another contributing factor appeared to be the stage of maturity of the berry when preserved. In the following series of experiments these two factors as possible causes of the toughening have been investigated.

Experimental.

Year 1942: Material and Methods.

The variety of gooseberry used was " Keepsake." The berries were picked at three different stages of maturity: under-ripe (June 12th), ripe (July 1st), and over-ripe (July 22nd). The fruit was weighed into one-pound " Kilner " type preserving jars, covered with the preservative and the lids of the jars screwed down tightly. Each jar contained 250 gm. of fruit and 210 ml. of solution.

In order to detect any difference which might be due to the type of preservative used, the fruit at each stage of maturity was preserved with solutions containing respectively sulphurous acid, potassium metabisulphite and sodium metabisulphite. Three solutions were prepared with each preservative, using distilled water, " Permutit "-softened tap water and ordinary tap water. Each solution contained the equivalent of 1,000 parts per million of sulphur dioxide. The hardness of the local supply of water was known to be due mainly to calcium salts. The calcium content of each type of water used was therefore determined (Table I). All calcium determinations were made volumetrically by precipitation as the oxalate.

The fruit was tested after nine months' storage at room temperature.

Calcium Content of Preserved Fruit. (*See Table I*).

The solid to liquid ratio of the contents of each jar was found. Approximately 100 gm. of the fruit was washed with a litre of distilled water, allowed

to drain overnight, weighed and ashed. The calcium contents of the covering liquid and fruit ash were determined.

The calcium content of the fruit preserved in solutions made with hard water was greatest in all cases.

Texture of Preserved Fruit. (*See Table I*).

The contents of jars from each series were boiled gently in open pans for fifteen minutes ; 2 oz. of sugar and 2½ fl. oz. of water were added and boiling continued for five minutes. When cold the samples were examined by a panel of tasters.

It was found that the gooseberries bottled on June 12th in distilled water were sufficiently soft ; those in softened water were less soft, while those in hard water were tough though edible when hot, but shrivelled and considerably tougher when cold. The berries bottled on July 1st gave similar results. Those bottled on July 22nd were all decidedly tougher than berries preserved earlier in the season, those in the hard water being so tough as to be almost inedible.

No difference was detected between fruit preserved with sulphurous acid, potassium metabisulphite and sodium metabisulphite.

Year 1943 : Material and Methods.

In 1943 a second series of experiments was carried out, in which mature " Keepsake " gooseberries were preserved in hard and distilled waters, each containing 1,000 parts per million of sulphur dioxide. The use of sodium metabisulphite and potassium metabisulphite was omitted as no difference had been detected in the previous year between fruits preserved with these and with sulphurous acid. The use of softened water was also omitted.

Samples of the fruit were also preserved by the " oven " method of bottling (1), in two series. In one, the fruit was covered with distilled water, and in the other, with hard water. Further samples were preserved in hard water by sterilization in a water bath (2). In all cases the solid to liquid ratio was again 250 gm. to 210 ml.

The calcium contents of the waters used for making the solutions and covering the fruit were noted (Table II) ; then after storing for five months the texture of the preserved fruit was tested and the calcium contents again determined.

Calcium Content of Preserved Fruit. (*See Table II*).

The procedure used for the previous series was again adopted. The amount of calcium contained by berries bottled by heat preservation in the hard water was in all cases at least 20 mg./100 gm. greater than that of berries bottled in distilled water. Fruit preserved with sulphurous acid in hard water showed the highest calcium content.

Texture of Preserved Fruit. (*See Table II*).

Samples of the fruit were prepared for tasting as before. When the contents of the jar had been sterilized by heat, fruit and liquid were brought to boiling point, sugar added, and boiling continued gently for five minutes.

The results of tasting tests agreed with those obtained in the 1942 series, the berries preserved in sulphurous acid solution made with hard water again being extremely tough and inedible. Gooseberries preserved by the " oven " and " water-bath " methods, using heat sterilization were equally soft whether bottled in hard or distilled water, and were slightly softer than those preserved in sulphurous acid solution made with distilled water.

Results.

TABLE I—1942 *RESULTS.*

Condition of Fruit.	Method of Preserving.	Ash of Preserved Fruit %	Ca (as $CaCO_3$) in Preserved Fruit.			Texture of Preserved Fruit.
			Liquid mg/100gm.	Fruit.		
				Ash %	Fresh Weight. mg/100gm.	
Slightly under-ripe	H_2SO_3 A	0.296	—	27.7	98	Tough
	$Na_2S_2O_5$A	0.331	6.41	23.3	81	Tough
	$Na_2S_2O_5$B	0.335	4.93	18.3	62	Fairly soft
	$Na_2S_2O_5$C	0.313	7.05	19.3	61	Soft
Ripe	H_2SO_3 A	0.275	9.85	23.3	63	Tough
	H_2SO_3 B	0.275	7.06	15.8	41	Fairly soft
	$Na_2S_2O_5$B	0.321	7.02	14.1	44	Fairly soft
	H_2SO_3 C	0.270	8.87	15.8	41	Soft
Over-ripe	H_2SO_3 A	0.279	—	21.8	53	Very tough
	H_2SO_3 B	0.272	—	19.0	46	Tough
	$Na_2S_2O_5$B	0.291	11.39	17.8	46	Tough
	H_2SO_3 C	0.272	—	18.8	45	Slightly tough

A = Ordinary tap water, Ca(as $CaCO_3$) 26 mg/100 gm.
B = 'Permutit'—softened tap water ,, 1 ,,
C = Distilled water ,, 0 ,,

TABLE II—1943 *RESULTS.*

Method of Preserving.	Ash of Fresh Fruit %	Ash of Preserved Fruit %	Ca (as $CaCO_3$) in Preserved Fruit.		Texture of Preserved Fruit.
			Ash %	Fresh Weight mg/100 gm.	
H_2SO_3 A	0.469	0.350	30.6	107	Very tough
,, B	,,	0.360	21.7	76	Slightly tough
'Oven method' A	,,	0.327	32.1	96	Soft
,, ,, B	,,	0.313	23.9	73	Soft
'Water-bath method' A	,,	0.313	31.3	100	Soft

A = Ordinary tap water, Ca (as $CaCO_3$) 25 mg/100 gm.
B = Distilled water ,, ,, 0 ,,

Note.—Figures given above are the means of those obtained on duplicate jars of preserved fruit.

Discussion.

Horner (3) has reported that the use of hard water in preparing the syrup does not appreciably toughen the skins of canned fruits. He used a " puncturing apparatus " for measuring relative degrees of toughness. In the work described here differences in toughness were so marked that they were readily detected without special apparatus. Results showed no appreciable difference in texture between gooseberries bottled in hard and distilled water when preserved by heat-sterilization methods, though there was a difference of at least 20 mg/100 gm. in the calcium content of the preserved fruits. This agrees with Horner's report, but mention must be made of the fact that he used syrup as the covering medium while in these tests water was used.

In view of the above, it is difficult to attribute the extreme toughness of the berries preserved with sulphur dioxide in hard water to an increase in calcium content. It does, however, appear that sulphurous acid itself has a definite toughening effect, and that this effect is greatly increased by the presence of calcium.

Summary.

The toughening of gooseberries preserved in hard water by the " Campden Method " has been demonstrated and a relationship indicated between degree of toughness and calcium content of the preserved fruit.

The absorption, to a lesser degree, of calcium from hard water by heat-sterilized gooseberries has been shown to produce no toughening effect.

Immature gooseberries are less tough when preserved in hard water by the " Campden Method " than are the mature or over-ripe berries.

REFERENCES.

(1) Ministry of Agriculture and Fisheries Bulletin 21, 12, 1942.
(2) Ministry of Agriculture and Fisheries Bulletin 21, 10, 1942.
(3) Horner, G. *Ann. Rept. Campden Res. Stn.* 1933–34, p. 49.

THE COST OF FARM LABOUR IN WARTIME.

By C. V. DAWE, M.Com., Ph.D. (Berkeley Square Advisory Centre).

Determination of Wage Rates.

In all matters appertaining to wages, whether in cash or in kind, and whether for normal working hours or for overtime, it is clear that no scientific approach exists at present to the problems involved. The various rates and allowances have, until recently, been settled by the separate County Wages Committees upon a mere bargaining, it may be even said, a haggling process. Fortunately, the time has now come when wages and allowances are settled upon a national basis, having due regard to conditions in other industries and the cost of living generally.

Sometimes one is tempted to say that wage rates in agriculture shall be determined upon an " economic basis " and in recent years considerable discussion has ranged around the problem of whether it is possible to determine and fix an economic wage for the agricultural industry. Such discussion has, however, always tended to assume a static position for agriculture, largely because it is impossible to judge the influence of national and international political, social, and economic, trends in the dynamic world of to-day. It is true, naturally, that there are extreme and absurd limits, both upwards and downwards, to which wage rates in agriculture, or, in fact, in any other industry may move. These limits are, on the one hand, a wage so low that workers would be so far below the existence level, or poverty line, that they would rapidly leave the industry ; on the other hand, so high that in spite of all the assistance possible of science and mechanical methods no net return whatever was left to the entrepreneur. Within these limits it is still possible that too low a wage will be uneconomic in the sense that in the long run only the inefficient workers remain in the industry since the efficient ones will have left to seek other better paid employment. Similarly, too high a wage in relation to what may be termed the customary or average efficiency of the worker will, while retaining efficient workers, so diminish the reward of enterprise among farmers that all progress in methods of production will cease.

One is left with the view that the term " economic wage " is meaningless ; the wage is determined partly by custom and partly by bargaining. The resistance to a rise in wage rates on the part of the employers varies inversely with the profitability, and directly with the depression of agriculture. For instance, it is clear from an analysis of wage adjustments as shown in the County Wages Orders, that only during a period of high profits, as in this war, are workers likely to receive any appreciable improvement in hours and wages. To what extent a " vicious circle " is liable thus to be created is not predictable. The workers, on the one hand, have not been slow to seize their opportunity during the war to obtain higher wages, and the employers on the other hand have not hesitated to impress upon the Government the additional expense thus incurred and the curtailment of their profits thereby entailed. It may rightly be argued that in the long run higher wages do not necessarily

mean high cost of production, but the ordinary man is usually more concerned with, or at least sees more clearly, the short run cause and effect. Moreover, these two forces interact over a long period, by a series of infinitely small variations, whereas in a short period, and especially during a war, the interactions are liable to be large and fairly sudden, *e.g.*, the considerable increases in wage rates and selling prices during the past three or four years.

Proportion of Labour Costs to Total Farm Costs.

While it is not possible to ascertain precisely the economic wage in agriculture, it is easy to state the proportion that the wages bill absorbs of the total costs in farming generally, by reference to data compiled by the Agricultural Economics Departments of the Colleges and Universities. Such a proportion does not mean that this represents the optimum point for labour cost nor that such a figure, translated into weekly wages, represents the " economic wage." It merely represents the effect of calculating the customary or average wage bill as a proportion of the total farm costs which in themselves vary from year to year and are subject to the innumerable influences of general economic conditions.

Bearing these reservations in mind, it may be stated that over the five-year period since 1938–9 the proportion of total farm costs absorbed by the labour bill has risen from 24% to 32%.* When the labour bill is offset against the total farm income, the proportion absorbed has remained fairly steady around 24% over the period. In making such comparisons the change that has occurred during the war in the composition of the labour force must not be overlooked. This change need not, however, prevent a comparison being made between the monetary values of the labour bill and of the farm output. Thus it can be stated that the total farm production for every £100 of labour cost was £420 in 1942–43 and £402 in 1941–42 compared with £451 in 1939–40 and £316 in 1938–39.* To what extent this improvement in output during the war is due to a more intense effort in regard to labour management in farm production generally on the part of the farmer, or to harder work on the part of the worker, is extremely difficult to say. The question is further complicated by the fact that the monetary value of the farm output has to be used, which involves the problems of price increases for various farm commodities, instead of making use of the actual physical output. This in turn is impossible owing to there being no other common denominator between crops and livestock.

From the farm accounts analysed in this Department, it is found that in the case of men and boys the cash earnings represent nearly the entire real wages, and only a small amount requires to be added for payment in kind. Probably a figure of 1/6 per week is sufficient for men, and a few pence for boys. In the case of women workers, however, the cash earnings form a much smaller proportion of total real wages, especially during the last two years, chiefly because a larger proportion of women workers are boarded in farmhouses and hostels, as, for example, are members of the W.L.A. The average value of such wages in kind can be put at approximately 4/- per week per worker.

The incidence of labour cost on farms can also be examined on an acreage

* Based upon an analysis of 118 farm accounts. See Departmental Bulletin " The Economic Aspect of Farming 1938–42."

basis. In 1942–43 it amounted to 90/- per acre of crops and grass, compared with 81/6 in 1941–42, 72/2 in the previous year and 57/6 in 1938–39. In arriving at this figure the cost of the manual work performed by the farmer has been included, on the assumption that if he did not himself perform such manual work, additional labour would have to be employed. The value of casual labour has also been included.

The difference over four years between 57/6 and 90/- per acre represents a rise of 57%, but if it be assumed that the average standard rate of wages for adult male workers in 1938–39 was approximately 34/- per week, and is now, at the time of writing 65/- per week, the percentage increase in standard rates amounts to 91%.

Substitution.

There has, of course, been a certain amount of substitution of skilled labour by relatively unskilled labour. This has not been of appreciable importance, but nevertheless must not be ignored when stating that the labour cost per acre has risen by 57%. Obviously had no substitution occurred, the labour cost would have only been a little higher than the present figure of 90/- per acre. In brief, therefore, the fact that the standard rates have increased by 91% and actual labour costs by approximately 57%, gives an indication of the greater efficiency of both workers and farmers and, in some measure, of the greater keenness in producing the larger food supply required by the community.

It is difficult to assess the degree of dilution of skilled labour which has occurred through the necessary employment of schoolboys and prisoners of war. Some impression may be obtained when it is mentioned that in the year before the war the total bill per farm for all types of casual labour amounted to only £23, compared with a bill of £27 in 1940–41 and £50 in the following year 1941–42, and with £97 in 1942–43. Even this last figure, however, is of minor importance, amounting to only 1/13th of the total labour cost.

Contract work has been of considerably greater importance during the war, but on the farms under review the value of work done by " outside " contractors has been almost offset by the work done by these farmers for other farmers.

The net result of this analysis of farm labour is that, with all the substitution of one form of labour by another that a war necessarily entails, the output of food depends primarily upon the mutual understanding and co-operation of the farmer and his regular staff. Both have received financial encouragement during the war, and in the difficult post-war period these higher standards of reward can only be maintained if the present higher standard of farming is maintained. The keynote is efficiency.

THE APPLICATION OF THE NATIONAL MILK TESTING AND ADVISORY SCHEME IN THE BRISTOL PROVINCE.

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In the 1942 Annual Report an account was given of the launching of the National Milk Testing and Advisory Scheme, introduced by the Ministry of Agriculture and Fisheries as an integral part of the Government's policy for the milk industry. In that article particular reference was made to the objects of the scheme and the specific tests applied to the milk samples. It is now proposed to describe the application of the scheme in the Bristol Province and to trace the progress achieved.

Scope of Scheme.

In scope and magnitude the scheme is unique since it envisages the establishment of machinery to ensure the regular keeping quality control of all producers' milk supplies. Hitherto the control of keeping quality has been in the hands of local health authorities, who were, and still are, responsible for the administration of the Milk and Dairies Order. At the same time progressive dairy firms exercised some unofficial control of supplies consigned to them. The result of such control was that varying standards were adopted by different local authorities and dairies.

Thus when the scheme was about to be launched, considerable intensive research was necessitated upon (i) the formulation of a suitable test for measuring keeping quality with accuracy, speed and a minimum of laboratory equipment, and (ii) having devised a satisfactory test, to prescribe reasonable keeping quality standards, for introduction on a national basis, for (*a*) the acceptance of producers' milk at depots and dairies, and (*b*) the commercial grading of milk for advisory purposes.

The writer was a member of a small committee formed to undertake this research work, and the committee's findings were adopted as a basis for testing supplies for the purposes of the scheme. A new test, the resazurin test, was recommended as it possessed advantages over all other tests for the particular work in view. The application of this test to meet practical conditions, the organisation of laboratory facilities and the training of personnel for the sampling and testing work have been tasks with which the provincial advisory bacteriologists have been confronted during 1943.

This work has assumed great importance in the Bristol Province which probably constitutes the most prominent dairying province in the country. Indeed, with some 18,000 milk producers and over 40 large depots and dairies, it is a fact that more milk " flows " in this province than in any other.

Organisation.

It was clear at the outset that, for administration purposes, the province would have to be divided into smaller units, or areas. The areas, each under the direction of a supervisor, are as follows :—

Area No.	*Area Covered.*
1	South and Mid-Somerset.
2	North Somerset, Bristol and South Gloucestershire.
3	Wiltshire.
4	North and Mid-Gloucestershire.
5	Herefordshire and Worcestershire.

Eventually each area will have an area laboratory where both routine and advisory tests can be conducted. At present, area laboratories are in operation at Bristol, Gloucester and Wincanton, while at Hereford a testing station—for routine testing only—has been established. It is hoped to obtain premises for area laboratories at Trowbridge and Worcester shortly.

The primary duties of the area supervisors are the organisation, supervision and control of all sampling and testing and the giving of advice on the handling and management of milk in depots and dairies. The supervisory functions entail regular and frequent visits—on the average once a fortnight—to the larger dairies where laboratories have been established by the dairy firms, and licensed to carry out tests for and on behalf of the Ministry of Agriculture and Fisheries. The personnel in these laboratories have to be trained, and when competent they are certificated to conduct the work.

Apart from the inspection and general supervision of the testers' work, the area supervisor has to keep a constant check upon the adequacy of the laboratory equipment and pay special attention to the cleanliness and sterility of the apparatus and materials used. The latter entails the frequent checking of glassware, bacteriologically, and of solutions chemically and bacteriologically.

In the whole province, 48 licensed trade laboratories have been established and these are staffed by 125 samplers and testers. This large team is responsible for the regular sampling and testing of some 15,000 producers' milk supplies consigned to the large depots and dairies.

With regard to advisory work, the area supervisors have concentrated their attentions upon the facilities and procedure adopted for churn cleansing at both large and small dairies. Frequent inspections of the cleansing methods are made and churn rinse samples are taken for examination bacteriologically to determine their degree of sterility. During the six months ending 30th Sept., 1943, more than 1,200 churns were tested in this way.

The organisation for the sampling of producers' milk consigned to small dairies which have not a laboratory of their own is based on the area laboratory. Itinerant sampler-testers have been appointed to the Advisory Bacteriologist's staff for sampling and testing these supplies.

The very small dairies—taking milk from fewer than four producers—and the producer-retailers constitute special difficulties in regard to sampling owing to the time and travelling necessitated in taking and transporting the samples. In a few areas sanitary inspectors are assisting with sampling and, in others, the itinerant sampling officers are undertaking the work.

For convenience in the administration of the scheme, dairies have been classified as follows :—

(1) Over-datum Dairies (more than 100 producers, or handling more than 2,000 galls. producers' milk daily. Samples tested in own licensed laboratory).

(2) Under-datum Dairies.

- (*a*) Small Units (10—99 producers. A few have their own licensed laboratory).
- (*b*) Very Small Units (4—9 producers).
- (*c*) Purchasing Retailers (3 or fewer producers).
- (*d*) Producer-Retailers (retail only their own milk).

Progress.

Briefly, the position to date is that 15,785 producers' supplies, which constitute approximately 90% of the total in the Province, are now subject to regular testing under the scheme. All supplies at dairies served by 4 or more producers are covered and the work is gradually being extended to the purchasing-retailer and producer-retailer supplies.

During the year ending 30th Sept., 1943, the number of routine tests conducted and the proportion of samples classed in the various categories according to keeping quality was as follows :—

No. of Tests.	*Categories.*		
	A	B	C
	%	%	%
222,456	73.1	18.0	8.9

Producers whose milk is in category " C " and is thus of poor keeping quality are reported to the county war executive committee so that advice on clean milk production can be given.

During the gradual expansion of the scheme many technical difficulties have been encountered, and considerable investigational work has been demanded in order to overcome them. Indeed, the application of the scheme has been a vast experiment, and the fact that so much progress has been made is evidence of its success.

THE REARING OF HEALTHY CALVES

By D. W. MENZIES, M.R.C.V.S., Veterinary Investigation Officer.

For many years the cause and treatment of disease has occupied the close attention of the scientist, but at the present time a much closer study is being made of the measures necessary for the prevention of those ailments which cause such a serious economic loss to the livestock industry. As far as the dairy industry is concerned, every effort is being made to grade up the quality from the production viewpoint and while this is being done, it is most desirable that the young stock should be treated in such a manner that they reach breeding age free from disease and fully capable of setting up a better record than their parents. There are still too many instances where young stock are not being given a fair chance and are being subjected unnecessarily to serious risk of infectious disease, the effects of which may not be observed for two or three years. Apart from correct feeding of calves, which is extremely important in itself, farmers by good management of their young stock can avoid many of the losses which they are at present sustaining.

It would probably be as well to begin with the pre-natal period of the calf. Cases have been encountered where in-calf cows are turned out on to poor pasture and given a little poor quality hay or oat straw. Bulky foods of poor feeding quality and pregnancy do not appear to go well together, and in a number of cases the cows have died. There must be many other border line cases where the cow just manages to survive and the result is bound to be a weakly calf. An adequate diet for in-calf cows is essential, particularly during the last few months of pregnancy, and while the available home-grown feeding-stuffs should be used as far as possible, there are now small reserves of cake which can be issued to farmers for the feeding of in-calf cows and heifers during the winter months.

After the birth of the calf, the animal runs the risk of infection with germs which cause inflammation of the intestines, scouring and in many cases death. There is also the risk, which is not so serious, that germs may gain entry through the unhealed navel and set up abscesses in various parts of the body, particularly the joints, with fatal results. The germs responsible for both conditions are sometimes though not always found in dirty buildings, and a number of such cases on a farm stresses the need for an isolation box where cows can calf down, a box so constructed that it can be readily cleaned out and disinfected, which means in most instances an impervious floor and walls of concrete. Both conditions are more common during the winter months, and there is no doubt that the calves are more susceptible to infection during this time owing to lack of sunlight. Attempts to rectify this by supplying Cod Liver Oil which contains Vitamin A have been carried out with very promising results, so that continuous small doses of Cod Liver Oil for very young calves are most desirable during the winter months.

There are other practices used when rearing calves which are most undesirable. For example, if there is a cow whose milk is abnormal or in some

instances obviously suffering from an inflamed udder, the practice often is to allow one or two calves to suckle her. In other cases a calf is put with a cow which may be losing condition or actively scouring and which is obviously in the last stages of Johne's Disease. In such cases the calf has every opportunity of contracting infection by sucking dung-soiled teats. The harm done may not be observable for two or possibly three years, and it is alarming the number of young animals just under two years of age which have been found to be suffering from advanced Johne infection.

In addition to Johne's Disease, there is another insidious infection for which there is also no cure, namely tuberculosis. This may be contracted by the calf through milk from a tuberculous udder, but there is another kind of infection which in many instances appears to be overlooked by the farmer. Tuberculosis can be air-borne. One animal in the herd may have infection of the lungs and breathes out tubercle bacilli which are carried about in the air of the cowhouse on particles of dust, many of which are inhaled by the other animals. Calves are sometimes tied up in the main cowshed for many days and while there they have every opportunity of contracting a tubercular lung infection at a time when they are very susceptible to the disease. Here again, we have a point in favour of the calving box and calf pens where the calf can be brought to the mother for feeding or the food brought to the calves.

It has been said that a sheep's greatest enemy is another sheep, and it is equally true that a bovine's greatest enemy is another bovine, both when the animals are housed and when they are turned out on pasture. There is a tendency when the calves go out on grass to put them in a field near home where they can be readily observed, but the difficulty is that the same field is often very useful as a hospital for sick cows, and is very often grazed for many months of the year by adult stock. The water supply to the field may be a modern drinking trough, but on too many occasions it is a pond which receives the effluent in whole or in part from the main farm buildings. The danger of water contaminated with the dung from adult animals is that it may contain the organisms of Johne's Disease, and the whole batch of calves may contract infection.

Turned out under these conditions, the calf also runs the very serious risk of picking up stomach and intestinal worm larvae left on the ground as eggs by the adult grazing stock. Adult animals can have considerable numbers of stomach and intestinal worms without showing any ill-effects, but wherever such animals graze, they leave behind them considerable numbers of worm eggs on the pasture which develop into larvae and are picked up by the grazing young stock. Young animals are much more susceptible to the effects of worms, and the incidence of Parasitic Gastro-Enteritis, as the disease is called, has been very much higher in the last few years among young cattle. The treatment of the disease is often delayed by the farmer until the animals are very markedly wasted, and once they reach this last stage and show no desire to feed, the treatment is often unsuccessful.

Extensive experiments have been carried out in America and New Zealand on the vaccination of heifer calves 4—7 months old for the control of Contagious Abortion. A calf inoculated at this period gives a positive reaction to the blood agglutination test, but by the time it reaches breeding age, the blood test is negative. At the same time, the animal is immune to Contagious Abortion. In those countries mentioned this method of calfhood vaccination has given

excellent results, and there is no reason why similar results should not be obtained in this country, because it is well recognised that calves which are reared on premises where abortion has been present for years develop an immunity through contracting infection at an early age. The Ministry of Agriculture is at present proposing to launch a scheme whereby all heifer calves between the ages of 4—7 months will be inoculated with the vaccine free of cost to the farmer. The final details are not yet available, but there is every reason to believe that the scheme will be launched in the very near future. The merits of such a scheme are obvious, as it will mean that the disease will be tackled on a national basis and will be an insurance against the very serious losses caused by abortion in those herds where vaccination is not practised and where every few years infection is introduced resulting in an abortion storm.

In brief, the farmer should aim at rearing his young stock free from contact direct or indirect with his main dairy herd. By so doing he will avoid the risk of infection with those diseases which are carried by the adult stock, apparently for a considerable period without ill-effect. Inoculation of his young stock with abortion vaccine will protect his animals against the ravages of abortion, and, after all, the young stock of to-day will be the dairy herd of to-morrow, and, as such, merits every attention that can be bestowed upon it.

REPORT ON ADVISORY WORK, 1942-1943.

The activities of the Advisory Service are now closely linked with those of the technical and district officers working under the County War Agricultural Committees. Co-operation has also been maintained with the county agricultural and horticultural officers. Individual advisers have been called upon for special assistance to the Ministries of Agriculture, Food, and Supply, to the Agricultural Research Council and the Agricultural Improvement Council.

The total of advisory letters sent in 1942–43 stands at 10,880, as compared with 10,352 in 1941–42. These enquiries are classified under the following headings :—Agriculture and Agricultural Chemistry, Dairy Bacteriology, Agricultural Economics, Veterinary Science, Pomology and Vegetable Culture, Horticultural Chemistry, Insecticides and Fungicides, Economic Entomology, Economic Mycology, Fruit Products, Domestic Preservation of Fruit and Vegetables, Cider, Cider Instruction, and Willows. The figures below refer to thirteen subjects, three dealt with at Berkeley Square and ten at Long Ashton. Figures for the preceding five years are added for comparison.

ENQUIRIES SUBMITTED TO THE DEPARTMENT 1938—1943.

	Year ended September 30th.					
	1938	1939	1940	1941	1942	1943
Gloucester (including Bristol)	1775	2264	1965	2491	2676	2908
Hereford	337	556	182	196	729	771
Somerset	1459	1117	1403	1479	2039	2491
Wiltshire	1328	1586	970	1410	1372	1691
Worcester	520	677	656	1010	1506	1491
Other Areas	1813	1516	2686	1776	2030	1528
	7232	7716	7862	8362	10352	10880

The principal increases in 1943 are in Dairy Bacteriology (+ 581), Veterinary Science (+ 407), and Pomology and Vegetable Culture (+ 202). As a result of the restricted scope of the Fruit Products work there was a decrease of 556 in advisory enquiries in this subject.

The Agricultural Officer and Adviser in Agricultural Chemistry records the acquisition by gift to the University of 450 acres of Mendip farmland affording facilities for carrying out field experiments and research on agricultural problems of both local and general interest.

The development of the National Milk Testing and Advisory Scheme has led to closer contact between the Adviser in Dairy Bacteriology, the milk producer and the dairyman, and has brought to light many new problems. The staff has been augmented to deal with the increased chemical work of the section.

In Agricultural Economics, the National Farm Survey, Milk Costings

Scheme and Farm Management Scheme continue to make satisfactory progress. Under the title of Enterprise Cost Studies, investigations have been started to ascertain the cost of production of a range of fruit and vegetables.

The principal work of the Veterinary Investigation Officer has been in the examination of specimens sent in to the laboratory. Co-operation with the practitioners in the Province has been maintained and is of the most cordial nature. Diseases under investigation include Mastitis, sterility in cattle, a cattle disease known as " Fog Fever," and Haematuria in lambs.

The Plantations Officer has continued the provision of demonstration allotments both at Long Ashton and in the City of Bristol. He acted as Technical Adviser to the Bristol Smallholdings and Allotment Committee until that body appointed their own Horticultural Instructor in August 1943.

Enquiries in Horticultural Chemistry dealt principally with crop failures on newly-ploughed land and manurial problems of gardens, allotments and glasshouses. Magnesium deficiency of tomatoes appears to be on the increase. A survey was made of the mineral deficiencies of the commercial fruit trials plot at Wisley and a series of manurial experiments was carried out on flax.

Under the direction of the Adviser in Economic Entomology the wireworm survey has been greatly developed in the Province. The Worcestershire growers have continued to make extensive use of the Field Laboratory at Evesham in obtaining information on pest control problems. The Research Entomologist has continued his assistance to the County War Agricultural Committees in the provision of spray machinery and the organisation of contract spraying.

In Economic Mycology, diseases of onions, tomatoes and potatoes received special attention both at Long Ashton and at the Evesham Field Laboratory. The Adviser assisted in the drawing up of a scheme for seed potato production in the Exmoor area.

Advisory work on Fruit Products was on a reduced scale compared with that of 1942. The most important series of enquiries arose from a visit to Northern Ireland, where great interest is being shown in the Long Ashton methods of utilising surplus fruit and vegetables.

The demand for the courses conducted by the Instructress in Fruit and Vegetable Preservation is now so heavy that only those with special qualifications are being accepted for training.

The wartime requirements for basketware have stimulated interest in willow-growing, but in the absence of a full-time advisory officer it has not been possible to give adequate attention to the industry.

Staff Changes.

Retirement :—(30.9.43) Professor B. T. P. Barker, M.A., as Director, succeeded by Professor T. Wallace, D.Sc.

Agriculture and Agricultural Chemistry.

Resignation :—Miss M. English, M.Sc., Senior Analyst.

Dairy Bacteriology.

Appointments :—Miss E. R. Bird, Assistant Advisory Bacteriologist;

Miss R. J. Boaz, N.D.D., Area Supervisor under the National Milk Testing and Advisory Scheme ; Miss M. Wallis, B.Sc., Chemist.

Agricultural Economics.

Appointments :—Mrs. D. S. L. Powell as Technical Assistant ; Mr. J. M. Pontin as Technical Assistant (Evesham area) ; Mrs. E. Cockell as Recorder, National Farm Survey.

Resignations :—Mr. M. Nussbaum, B.A., Technical Assistant ; Mr. L. M. Marshall, Recorder, National Farm Survey.

Veterinary Science.

Appointment :—Mr. R. W. Roach, B.Sc., M.R.C.V.S., as Assistant Veterinary Investigation Officer.

Fruit Products.

Resignation :—Mr. V. L. S. Charley, Ph.D., Fruit Products Officer.

PUBLICATIONS,

1943.

LONG ASHTON RESEARCH STATION.

BARKER, B. T. P.

"Agricultural and Horticultural Research in War-time. (Bath and West and Southern Counties Society Pamphlet No. 10, 58 pp., Bath, 1943).

BERRY, W. E. *et al.*

"The Absorption and Accumulation of Solutes by Living Plant Cells." (Ann. Bot., VII, 221–260, 1943.

CHARLEY V. L. S. and POLLARD, A.

"Spray-dried Rose Hip Powder." (Nature, CLII, 354, 1943).

CRANG, B. ALICE.

"Domestic Preservation of Fruit and Vegetables." (Min. of Agr. Bull. No. 21, 74 pp. H.M.S.O. Revised Edition, January 1943).

CROXALL, H. E.

"Root and Stem Diseases of Cereals." (Worcs. County Council Quarterly Agr. Chron., XI, 335–341, 1943).

HICKMAN, C. J.

"Shanking: a new Disease of Onion and Shallot." (Gard. Chron., CXIV, 130, 1943).

HICKMAN, C. J. and ASHWORTH, D.

"The Occurrence of *Botrytis* spp. on Onion Leaves with Special Reference to *B. squamosa*." (Trans. Brit. Myc. Soc., XXVI, 153–157, 1943).

HICKMAN, C. J., MARSH, R. W. and WILKINSON, E. H.

"Preliminary Experiments on the Use of Oil-Soluble Copper Compounds as Fungicides." (Ann. Appl. Biol., XXX, 179–183, 1943).

KEARNS, H. G. H.

"War-time Spray Programmes for Fruit in the West Country and West Midlands." (Hort. Edu. Assn. Occasional Publication on Sci. Hort., No. 4, 66–70, 1943).

MARTIN, H.

"War Problems and Post-war Responsibilities of the Association." Presidential Address to the Association of Applied Biologists. (Ann. Appl. Biol., XXX, 109–116, 1943).

"The Evaluation of Fungicides: a Study in Quantitative Toxicology." (Journ. Soc. Chem. Ind., LXII, 67–70, 1943).

MILES, H. W.

"Turnip Flea Beetles." (Agriculture, L, 36–38, 1943).

OGILVIE, L.

"Control of Vegetable Diseases in War-time." (Hort. Educ. Assn. Occasional Publication on Sci. Hort. No. 4, 22–24, 1943).

PARKER-RHODES, A. F.

"Studies on the Mechanism of Fungicidal Action. V. Non-Metallic and Sodium Dithiocarbamic Acid Derivatives." (Ann. Appl. Biol., XXX, 170–179, 1943).

"Studies on the Mechanism of Fungicidal Action. VI. Water." (Ann. Appl. Biol., XXX, 372–378, 1943).

WAIN, R. L. *et al.*

"The Fate of Manganese Sulphate in Alkaline Soils." (Journ. Agr. Sci., XXXIII, 18–22, 1943).

WAIN, R. L. and WILKINSON, E. H.

"Studies upon the Copper Fungicides. VI. The Solution of Copper from Bordeaux and Burgundy Mixtures." (Ann. Appl. Biol., XXX, 379–391, 1943).

"A New Copper Seed Protectant." (Gard. Chron., CXIII, 27, 1943).

WALLACE, T.

"The Diagnosis of Mineral Deficiencies in Plants by Visual Symptoms: a Colour Atlas and Guide." (116 pp., H.M.S.O., 1943).

"The Renovation of Starved Orchards by Cultivation and Manuring." (Hort. Educ. Assn. Occasional Publication on Sci. Hort. No. 4, 55–56, 1943).

"Mineral Deficiencies in Vegetable and Fruit Crops: Visual Methods of Diagnosis." (Hort. Educ. Assn. Occasional Publication on Sci. Hort. No. 4, 55–56, 1943).

WALLACE, T. and WAIN, R. L.

"The Blackening of Cooked Potatoes." (Agriculture, L, 425–428, 1943).

WILKINSON, E. H.

"Perennial Canker of Apple Trees in England." (Gard. Chron., CXIV, 159, 1943).

"Dry Eye Rot of Apples caused by *Botrytis cinerea* Pers." (Journ. Pomology Hort. Sci., XX, 84–88, 1943).

BERKELEY SQUARE ADVISORY CENTRE.

COOK, L. A. C.

"Poultry Costings Bulletin." (Bristol Univ. Dept. of Agr. Bulletin, June, 1943).

DAWE, C. V.

"Farm Labour in the South-West." (Farm Economist, IV, 53–54, 1942).

"Annual Farm Account Tables." (Bristol Univ. Dept. of Agr. Bulletin, October, 1942).

DAWE, C. V. and COOK, L. A. C.

"Economic Aspects of Farming, 1938–42." (Bristol Univ. Dept. of Agr. Bulletin, December, 1942).

"Costs of Production of Corn Crops; Cropping Year 1942." (Notes on Farm Economics, New Series, No. 1, November, 1943).

"Costs of Production of Crops and Milk." (Bristol Univ. Dept. of Agr. Bulletin, December, 1943).

EGDELL, J. W. and THOMAS, S. B.

"A Comparison of the Results of Methylene Blue and Routine Resazurin Tests." (Proc. Soc. Agric. Bacteriologists (Abstracts), 1943).

EGDELL, J. W. *et al.*

"A Comparison of Rapid Platform Tests for the Bacteriological Quality of Milk." (Dairy Industries, VIII, 215–223, 1943).

LING, A. W.

"Hay: Its Composition and Nutritive Value." (Agriculture, L, 106–109, 1943).

LING, A. W. and SMITH, E. L.

"Hay: Its Composition and Nutritive Value." (Worcs. C. C. Quarterly Agr. Chron., XI, 221–229, 1943).

MENZIES, D. W.

"Mastitis of Dairy Cattle." (Worcs. C. C. Quarterly Agr. Chron., XI, 115–117, 1943).

ROACH, R. W.
"Two Cases of Avitaminosis A encountered in Poultry." (Veterinary Record LV, 265, 1943.

ROACH, R. W. *et al.*
"Sulphanilamide in the Treatment of Group C and Group G Streptococci Infection: Mouse Experiments." (Veterinary Journ. XCIX, 42, 1943).

STEWART, R.
"Observations on Silage." (Journ. R. Lancs. Agric. Soc., 21–24, 1943).

CAMPDEN RESEARCH STATION.

ADAM, W. B.
"Factors Affecting the Vitamin C Content of Canned Fruits and Vegetables—Progress Report II." (Annual Report of the Fruit and Vegetable Preservation Research Station, Campden, Glos., 1942, 12–17, July, 1943).

ADAM, W. B. and DICKINSON, D.
"Fruit Gumming of Victoria Plums—Progress Report IV." (*Ibid.*, 1942, 27–32).
"Notes on the Determination of Solids and Sugars in Canned Beans." (*Ibid.*, 1942, 33–36).

DICKINSON, D.
"The Chemical Determination of Minute Amounts of Boron." (*Ibid.*, 1942, 18–26).
"A New Colorimetric Method for the Determination of Boron." (Analyst, LXVIII, 106–109, 1943).